An Ecosystem of Citizen Observatories for Environmental Monitoring

D2.1 EU Citizen Observatories Landscape Report - Frameworks for mapping existing CO initiatives and their relevant communities and interactions

Work package	WP2: SUPPORT: CO-CREATE AND STRENGTHEN THE CITIZEN OBSERVATORIES KNOWLEDGE BASE
Task	Task 2.1: Map EU landscape of existing citizen observatories initiatives, relevant communities and their interactions (Lead: ECSA; Participants: UNESCO-IHE, IIASA)
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Table of Contents

Index of figures

Index of tables

List of abbreviations and acronyms

Abbreviation	Meaning
CAISE	Center for Advancement of Informal Science Education
COs	Citizen Observatories
CoPs	Communities of Practice
EC	European Commission
ECSA	European Citizen Science Association
EO	Earth Observation
EU	European Union
FP7	Seventh Framework Program
H2020	Horizon 2020 Funding Program
ICT	Information and Communication Technology
PPSR	Public Participation in Scientific Research

1 Executive Summary

Citizen Observatories, which invite the public to contribute observations, data and information to community-based environmental monitoring programmes, can play an important role in crucial areas such as climate change, sustainable development, air monitoring, flood and drought monitoring, land cover or land-use change.

Amongst the benefits of Citizen Observatories are that these contributions can be used to complement authoritative, traditional in-situ and r30/07/2018emote sensing Earth Observation data. Citizen Observatories can also provide new data sources for policy-making, and they can result in increased citizen participation in environmental management and governance at a large scale.

With the increasing prevalence of Citizen Observatories globally, there have been calls for a more integrated approach to handling their complexities, and to sharing crucial knowledge for the design and management of stable, reliable and scalable Citizens' Observatory programmes. Answering this challenge in the European context, the Horizon 2020-funded project WeObserve aims to improve coordination between existing Citizen Observatories and related European activities, while tackling three key challenges that inhibit the mainstreaming of citizen science: *Awareness*, *Acceptability*, and *Sustainability*.

Systematically tackling these challenges first requires the aggregating, building and strengthening of the Citizen Observatory knowledge base. The first step in doing so is to map the EU landscape to identify the existing Citizen Observatory networks and their associated ecosystems and stakeholders, in order to gain insights into the development, operation and challenges facing Citizen Observatories in Europe.

This Landscape Report forms the first part of this dynamic exercise to establish the frameworks for describing and comparing Citizen Observatories in Europe (*Deliverable 2.1 - Frameworks*), a follow-up Landscape Report that Maps the Citizen Observatories in Europe (*Deliverable 2.1 - An Overview of COs in Europe*), and the final Landscape Report in Month 24 of the project (*Deliverable 2.4 - The Landscape of COs in Europe*).

1 Introduction

1.1 Background

There are a growing number of Citizen Observatories (COs), which have been supported via the European Union's Seventh Framework Program (FP7) and continue to be funded in Horizon 2020 (H2020). COs, which are supported by innovative technologies including Earth Observation (EO) and mobile devices, are the means by which communities can monitor and report on their environment and access information that is easily understandable for decision making[1].

Under FP7, five COs were funded, covering a diverse range of environmental issues including biosphere monitoring (COBWEB), odour monitoring (OMNISCIENTIS), air pollution monitoring (CITI-SENSE), flood and drought monitoring (WeSenseIt) and coastal and marine water quality monitoring (Citclops). These projects aimed at "developing novel technologies and applications in the domain of Earth Observation, trying to exploit the capabilities offered by portable devices (smartphones, tablets or microsensors), to enable an effective participation by citizens in environmental stewardship based on broad stakeholder and user involvement in support of both community and policy priorities"[2].

Lessons learned in these projects[3] are now being implemented in the currently-live COs funded by H2020 (Ground Truth 2.0, GROW, LandSense, Scent), and new projects funded by H2020 that are just starting to kick off (D-Noses and MONOCLE).

The WeObserve project has been formed in order to support and consolidate these ongoing efforts,

1.2 Mission and goals of the WeObserve project

WeObserve is a Coordination and Support Action which tackles three key challenges that Citizens Observatories (COs) face: *Awareness*, *Acceptability* and *Sustainability*. The project aims to improve the coordination between existing COs and related regional, European and international activities. The WeObserve mission is to create a sustainable ecosystem of COs that can systematically address these identified challenges and help to move citizen science into the mainstream.

The core goals of the WeObserve project are to:

1. Develop communities of practice around key topics to assess the current CO knowledge base and strengthen it to tackle future environmental challenges using CO-driven science,
2. Extend the geographical coverage of the CO knowledge base to new communities and support the implementation of best practices and standards across multiple sectors,
3. Demonstrate the added value of COs in environmental monitoring mechanisms within regional and global initiatives such as GEOSS, Copernicus and the UN Sustainable Development Goals, and
4. Promote the uptake of information from CO-powered activities across various sectors and foster new opportunities and innovation in the business of in-situ earth observation.

[1] Rubio-Iglesias, J.M. 2013. Citizens' observatories for monitoring the environment: A commission perspective. In Proceedings of the Workshop on Citizen's Involvement in Environmental Governance, Arlon, Belgium, 7 October 2013; Directorate General Research and Innovation, European Commission: Brussels Belgium

[2] Horizon 2020 Open Conference *Citizens' Observatories: Empowering European Society*, Brussels December 4th, 2014 event description: https://ec.europa.eu/programmes/horizon2020/en/news/citizens%E2%80%99-observatories-empowering-european-society-open-conference

[3] European Commission. 2014. Citizens' Observatories. Empowering European Society Conference Report. Version 1.0, Brussels, Belgium, 4th December 2014. Climate Actions and Earth Observation Unit in DG Research and Innovation.

The delivery of this first objective, to develop CO communities of practices, is contained within Work Package 2 of the WeObserve project, and the first task therein is to map the EU landscape of existing CO initiatives, relevant communities and their interactions.

1.3 Purpose of this report

This Landscape Report forms the first in a series of reports to be delivered by Task 1 and Task 4 within Work Package 2, to '*Map the EU landscape of existing citizen observatories initiatives, relevant communities and their interactions*'. Their purpose is to deliver directly on the first two objectives of WP2, to:

1. Enhance the baseline analysis of existing and emerging CO initiatives, related communities and their interactions, and
2. Strengthen the knowledge base about COs, both from the perspective of the practitioner in terms of benchmarking existing initiatives as well as a social science perspective to reinforce the 'science of citizen observatories'.

These reports also aim to provide insight and structure for the delivery of the third and fourth WP2 objectives, to:

3. Launch and coordinate five WeObserve Communities of Practice (CoPs) on relevant themes to consolidate the knowledge on COs inside as well as beyond the consortium, which will address best practices, barriers and synergies between environmental COs, related communities and existing relevant activities, and
4. Coordinate the four forums associated with the CoPs and provide matchmaking and networking opportunities for stakeholders to connect.

1.4 Scope of this report

The process of writing this report is a dynamic exercise across the first two years of the WeObserve project, with three distinct iterations across two deliverables:

D2.1 - EU Citizen Observatories Landscape Report - Frameworks for mapping existing CO initiatives and their relevant communities and interactions. This first report sets the foundations for the description and categorisation of COs in Europe by establishing a working definition of COs, identifying the frameworks to describe them and benchmark them for comparative purposes, to assess them for best practice, and and to evaluate them for impact.

D2.1 - Overview of COs in Europe (online). The description of the COs and visualisations of the networks of COs in Europe will be shared online at www.weobserve.eu upon launch of the WeObserve Knowledge Hub.

D2.4 - EU Citizen Observatories Landscape Report - Final Report. The final report to be completed in Month 24 of the WeObserve project will expand upon the selected short list of COs to capture a wider range of top-down and bottom-up projects across Europe, including those that do not necessarily identify themselves as such, but do meet the definition of a CO.

The selected projects that comprise the scope of the '**D2.1 Frameworks Report'** are the COs funded by the European Commission's FP7 programme, and the H2020 funded COs that are connected with the WeObserve project, as listed in Table 1 below.

TABLE 1: THE CITIZEN OBSERVATORIES SELECTED FOR D2.1 REPORTS

FP7 - funded COs	Focus	Timeline
COBWEB	Biosphere monitoring	2012 - 2016
OMNISCIENTIS	Odour monitoring	2012 - 2014
CITI-SENSE	Air pollution monitoring	2012 - 2016
WeSenseIt	Flood and drought monitoring	2012 - 2016
Citclops	Coastal and marine water quality monitoring	2012 - 2015
H2020 - funded COs		
Ground Truth 2.0	Flora and fauna, water availability and water quality, for land and natural resources management	2016 - 2019
GROW	Soil, land-use, crop planting, and water resources	2016 - 2019
LandSense	Land use and land cover	2016 - 2019
Scent	Water supply & quality, flood risks	2016 - 2019

This first '**D2.1 - Frameworks**' report consists of a desktop review of the CO literature to establish a working definition of COs and to select suitable frameworks for the subsequent reports, which can be used to describe and categorise the short-list of projects, and assess and compare a wider range of projects in the final report. The outcomes will be shared online at www.weobserve.eu.

The final '**D2.4 - Landscape Report**' will consist of an in-depth analysis based on social science methods, which will include at least 5 focus groups organised in parallel with planned WeObserve CoPs workshops and events, and approximately 20 in-depth interviews with key selected stakeholders. The information gathered through these instruments will provide detailed and qualitative information on the current and past COs, which augment the initial inventory exercise outlined in this report.

Throughout the entire research period, the analytical approaches will aim to:

1. Understand the reasoning and functioning of interactions among key COs and existing networks/associations, including (where possible) a needs and gap analysis, and
2. Survey the interactions in a multi-stakeholder approach, with particular emphasis on the interactions between COs and the ways in which knowledge has moved and continues to move between them.

3 Methodology

The first phase of this dynamic exercise across the first two years of the WeObserve project primarily consists of desktop research to establish working definitions and frameworks by which the COs can be described and categorised, in preparation for more in-depth research and analysis in the second phase.

In order to establish the descriptive terms by which we can compare the selection of COs listed in Table 1 above, we start by conducting a review of the relevant literature to select a number of useful frameworks for categorisation purposes. Elements taken from each of these frameworks have contributed to the creation of the Project Description Template contained in Appendix 1. This template is being used to create the individual project descriptions that will be shared online at www.weobserve.eu.

During the review of the literature, frameworks which will prove useful for assessment and evaluation purposes are also being identified for use in the final D2.4 Landscape Report. This second phase will entail conducting a range of face-to-face interviews and workshops with key project initiators and stakeholders. The analytical and evaluative methodologies will be developed iteratively throughout the project.

4 Frameworks for Mapping the Landscape of Citizen Observatories in Europe

In order to map the landscape of COs in Europe, we start by establishing a working definition of what makes a CO, and how that fits into the large landscape of Citizen Science. We accomplish this by performing a review of the CO literature.

4.1 What is a Citizen Observatory?

The first use of the term 'Citizen Observatory', to our knowledge, appears in Prof. Jacqueline McGlade's 2009 Earthwatch Lecture entitled '*Global citizen observatory - The role of individuals in observing and understanding our changing world'*, wherein she stated that "it is no longer sufficient to develop passive lists or reports to 'inform' citizens of changes in our environment. We need to engage with citizens and ask how they can 'inform' us."[4]

In her abstract for the Lecture, she calls on such earth observation systems as the Global Monitoring for Environment and Security (GMES) (now known as Copernicus) and the Shared Environmental Information System (SEIS) to obtain and use local knowledge to "help us empower citizens, and ... give us a better indication of what we need to do to be truly sustainable."[5]

The concept of a CO has since been taken up within the European Commission, as using

> "*innovative earth observation technologies (in particular those based on use of mobile telephony) . . . [and] community-based environmental monitoring, data collection, interpretation and information delivery systems; empower communities with the capability to monitor and report on their environment; and enable communities to access the information they need to make decisions in an understandable and readily usable form*"[6]

Rubio-Iglesias (2013) describes COs as having at least four distinctive features:

1. Bidirectional information flows, i.e., "*citizens are recipients of information but also important providers*".
2. New citizen functions, e.g., "*the public should be given the means to aggregate, combine and generally reuse information according to their various needs*".

[4] McGlade J: Global citizen observatory - The role of individuals in observing and understanding our changing world. Annual Earthwatch lecture - Citizen Science, Oxford, 16th February 2009 http://www.eea.europa.eu/media/speeches/global-citizen-observatory-the-role-of-individuals-in-observing-and-understanding-our-changing-world

[5] McGlade 2009

[6] Rubio Iglesias, J.M. Citizens' observatories for monitoring the environment: A commission perspective. In Proceedings of Workshop on Citizen's Involvement in Environmental Governance, Arlon, Belgium, 7 October 2013; Directorate General Research and Innovation, European Commission: Brussels, Belgium, 2013. (As quoted in Grainger 2017)

3. Support for multi-scalar governance, e.g., "*participation in assessing the success of European Union (EU) environment policies*".
4. Complementarity, e.g., "t*he potential to enormously expand in situ monitoring capability, and ...limit the charge on the public purse...*"[7]

The Horizon 2020 Call '*SC5-17-2015: Demonstrating the concept of 'Citizen Observatories''* , built on the definition of the community-basis of COs to expand their applicability into the private and public sectors:

> *"New in-situ observatories ('Citizen Observatories') based on citizens' own devices (e.g. smart phones, tablets, laptops, and other social media) used together with innovative technologies can strengthen environmental monitoring capabilities, have the potential to generate new and original applications to reduce investment and running costs of in-situ observations and monitoring applications and solutions, and involve novel partnerships between the private sector, public bodies, NGOs and citizens. "* [8]

The Horizon 2020 CSA Call '*SC5-19-2017: Coordination of citizens' observatories initiatives*' draws the connection more explicitly with Earth Observation networks, defining COs as

> *"community-based environmental monitoring and information systems which build on innovative and novel Earth observation applications embedded in portable or mobile personal devices. Thanks to the vast array of ubiquitous information and data they can provide, citizens' observatories can enable authorities to obtain evidence and inform environmental policy making, complementing more authoritative in-situ observation and monitoring networks and systems with a very positive cost-benefit ratio." * [9]

In their 2014 paper '*A conceptual approach to a citizens' observatory—Supporting community-based environmental governance*', Liu et al. place COs solidly in the context of environmental governance, which for them refers to the "processes of decision-making involved in the control and management of the environment for the purpose of attaining environmentally-sustainable development."[10] Their definition of a CO is as follows:

> "*A CO for supporting community-based environmental governance may be defined as the participation of citizens in monitoring the quality of the environment they live in, with the help of one or more of the following: (1) mobile devices of everyday utility; (2) specialized static and/or portable environmental and/or wearable health sensors, and (3) personal, subjective and/or objective observations, information, annotation and exchange routes, coming from social media technologies or other similar platforms*. "

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[7] Grainger, A. (2017). Citizen Observatories and the New Earth Observation Science. Remote Sensing, 9(2), 153. doi:10.3390/rs9020153, (quoting Rubio Iglesias 2013)

[8] European Commission Research & Innovation Participant Portal https://ec.europa.eu/research/participants/portal/desktop/en/opportunities/h2020/topics/sc5-17-2015.html (last accessed 26 June 2018)

[9] European Commission Research & Innovation Participant Portal https://ec.europa.eu/research/participants/portal/desktop/en/opportunities/h2020/topics/sc5-17-2015.html (last accessed 26 June 2018)

[10] Liu, H.-Y.; Kobernus, M.; Broday, D.; Bartonova, A. A conceptual approach to a citizens' observatory—Supporting community-based environmental governance. Environ. Health 2014, 13, 107.

Working definitions for COs have also been put forth by different FP7-funded projects. For example, the CitiSense project defined a CO for community-based environmental governance as

> "*the citizens' own observations and understanding of environmentally related problems and in particular ... reporting and commenting on them within a dedicated ICT platform*."[11]

while the WeSenseIt project defined a CO in a broader sense as

> "*a method, an environment and an infrastructure supporting an information ecosystem for communities and citizens, as well as emergency operators and policymakers, for discussion, monitoring and intervention on situations, places and events*."[12]

Within the CITISENSE project, Liu et al. (2014) develop a conceptual framework for COs, that proposes 4 main aspects of what makes a CO. The first three all emphasise the idea of bidirectionality, i.e. collaborative participation, bidirectional interactive communication and bidirectional approaches (i.e. top down and bottom up). The final aspect is about inputs to the system, i.e. one from citizens and the other from sensors. Namely:

1. "Collaborative participation,
2. Two data layers, in which a "hard layer" is generated by sensors and a "soft layer" by citizens,
3. A bidirectional (top-down and bottom-up) approach; and
4. Bidirectional interactive communication"[13].

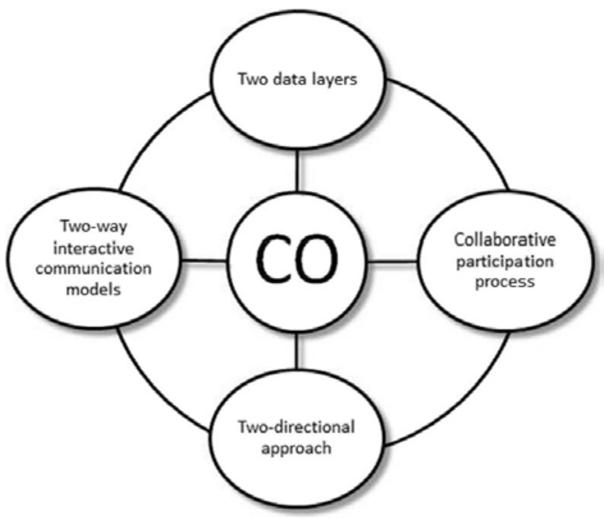

FIGURE 1: CONCEPTUAL FRAMEWORKS TO A CITIZENS' OBSERVATORY - LIU ET AL 2014

Alan Grainger, in the Special Issue of Remote Sensing on Citizen Science and Earth Observation, defines COs much more simply as

[11] *Liu et al 2014.*

[12] *Ciravegna, F., Huwald, H., Lanfranchi, V., and Wehn de Montalvo, U. (2013). Citizen observatories: the WeSenseIt Vision. In proceeding of the Infrastructure for Spatial Information in the European Community (INSPIRE 2013). Florence, Italy, 23–27 June, 2013.*

[13] Liu et al. 2014

> "*any use of Earth observation technology in which citizens collect data and are empowered by the information generated from these data to participate in environmental management.*"[14]

Looking at these different definitions, the main commonalities are the participation of citizens in environmental monitoring and governance, the bi-directional flow of data and information, the enhancement of earth observation systems with citizen-generated observations 'in situ', and the use of modern mobile and web technologies to do so.

For the purposes of this first iteration of the Landscape Report, our selected shortlist of projects have self-identified themselves to be COs. However, in the final version of the report (D2.4) we will explore these definitions further, as we expand the report to encompass projects that fit the definition of a CO, but do not call themselves such, and may not even be familiar with the term.

4.2 How do Citizen Observatories fit within the wider field of Citizen Science?

In attempting to place COs into the wider field of Citizen Science, we look first to the Scientometric Meta-Analysis performed by Kullenberg & Kasperowski in 2016[15] to discover the number of terms used in relation to 'citizen science' in the scientific literature (see Figure 2 below). When taking the sub-group of volunteer contributions that consists of participation in observations, classification and collection of data as a focal point , they found

> "*important synonyms to the concept of CS in this case, including ' community-based monitoring', ' volunteer monitoring' and ' participatory science', all designating the contribution of non-scientists to (primarily natural-) science*"[16]

Interestingly, the terms 'observatory' or 'citizen observatory' did not arise in their analysis.

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[14] Grainger, 2017

[15] Kullenberg C, Kasperowski D (2016) What Is Citizen Science? – A Scientometric Meta-Analysis. PLOS ONE 11(1): e0147152. https://doi.org/10.1371/journal.pone.0147152

[16] Kullenberg & Kasperowski 2016

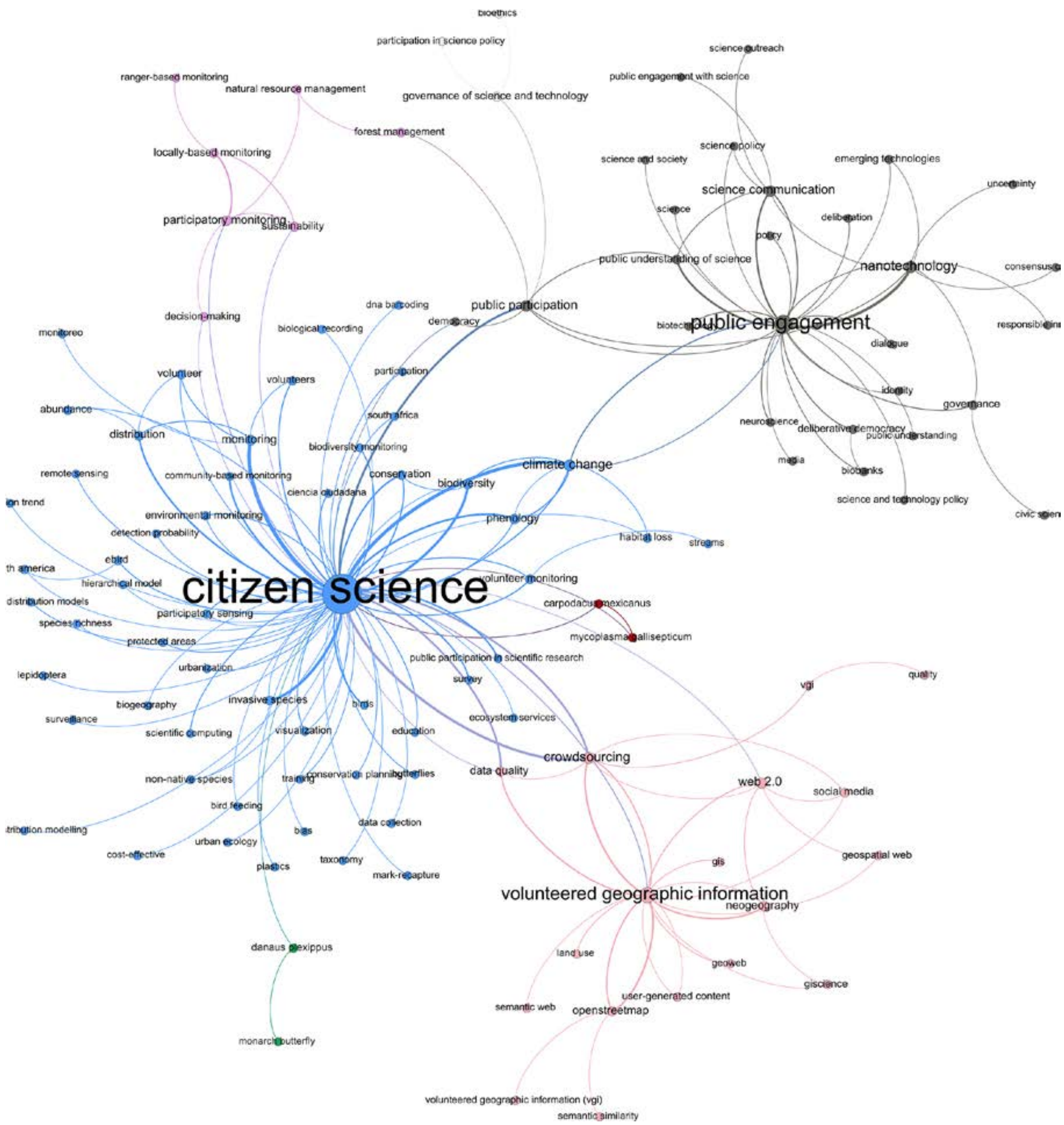


FIGURE 2: CONCEPTUAL STRUCTURE OF CONTEMPORARY CITIZEN SCIENCE - KULLENBERG & KASPEROWSKI 2016[17]

Performing a similar search via Google Scholar in October 2016, Grainger only found

> *"four publications in international peer-reviewed journals whose titles include "citizen observatories" or "citizen observatory" (or their citizens' equivalents), compared with 14,300 publications with "Landsat" in their titles. Two of the publications are derived from the same citizen observatory project—WeSenseIt; the others come from two other projects—Citisense and COBWEB. [18]"*

[17] Kullenberg and Kasperowski 2016. https://doi.org/10.1371/journal.pone.0147152.g004

[18] Grainger 2017, pg.2

However, the systematic review of 10 years of CO literature (1/1/2004 – 31/06/2015) undertaken by the Finnish Environmental Institute and Lappeenranta University of Technology[19] yielded a much higher number of search results, as shown in Table 2 below.

TABLE 2: NUMBER OF RESULTS PER DATABASE - PALACIN-SILVA ET AL. 2016

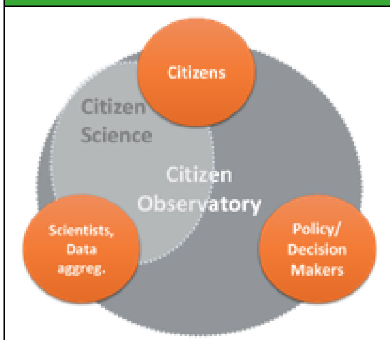
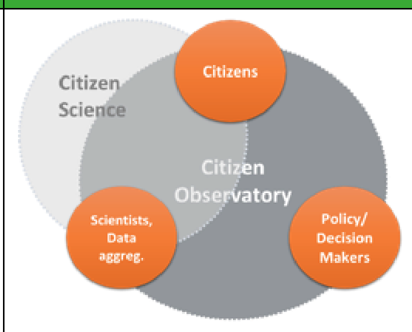
Database	Date	citizen* AND observ* OR repository* AND environment	citizen* AND engagement* AND environ AND observ*
IEEE Digital Library	27.7.2015	1981	7275
ACM Digital Library	28.7.2015	13	347
Sciencedirect	28.7.2015	2589	4339
Web of Science	28.7.2015	6689	15
Springer Link	28.7.2015	39980	5079

Grainger went on to define COs as differing from Citizen Science in two main ways:

> *"a. The information which they generate must, by definition, directly benefit citizens and society generally, rather than science alone, as in much conventional citizen science. Data collected by citizen scientists have so far had relatively few practical applications.*
>
> *b. They will be organizationally more complex than previous citizen science projects, most of which were only contributory projects. Owing to the greater participation of citizens from an early stage, most citizen observatories are likely to fall within the categories of co-created projects or collaborative projects."* [20]

At the launch of the first WeObserve CoPs following the ECSA 2018 Conference in Geneva, we asked 'Are Citizen Observatories a sub-set of Citizen Science, outside Citizen Science but overlapping, or something else?' (See Table 3 below).

TABLE 3: THE DELINEATIONS BETWEEN CITIZEN SCIENCE AND CITIZEN OBSERVATORIES DISCUSSED AT THE COP LAUNCH WORKSHOPS IN GENEVA, 2018

i) CS as a subset of COs	ii) CS as subset of COs and beyond	iii) COs as subset of CS
		

[19] Palacin-Silva, M.; Seffah, A.; Heikkinen, K.; Porras, J.; Pyhälahti, T.; Sucksdorff, Y.; Anttila, S.; Alasalmi, H.; Bruun, E.; Junttila, S. (2016) State-of-the Art Study in Citizen Observatories: Technological Trends, Development Challenges and Research Avenues; Finnish Environment Institute: Helsinki, Finland, 2016.

[20] Grainger 2017, pg 5

Consensus among the participants in the CoP1 '*Co-design and citizen engagement*' workshop and CoP2 '*Impact and value of COs for governance*' workshop converged around image iii) In Table 3 above, namely that COs present a specific form of Citizen Science, characterised by their focus on observing the environment (rather than other phenomena), the scale of their activities (typically local) and their time line (typically long term).[21]

4.3 Describing & Categorising Citizen Observatories

In order to assess and compare the short-list of COs selected for this first Landscape Report, the projects must first be categorised and described in a consistent fashion. We have therefore conducted a review of the relevant literature to select a number of useful frameworks for this purpose. These are described below.

Each of these frameworks has contributed to the creation of the Project Description Template contained in Appendix 1, which we used for each of the Project Descriptions that are shared online in the Landscape of COs section of the WeObserve website at: https://www.weobserve.eu/.

4.3.1 Pallacin-Silva's 8 Domains of Application

In their systematic study of 108 ICT-enabled participatory sensing projects[22], Palacin-Silva & Porras classified the COs into eight sub-themes based on their monitoring domain (See Figure 3 below), most of which were "focused on some level of environmental monitoring such as species, water, streams, snow, sea, biodiversity, air, spectrum, and global monitoring."[23]

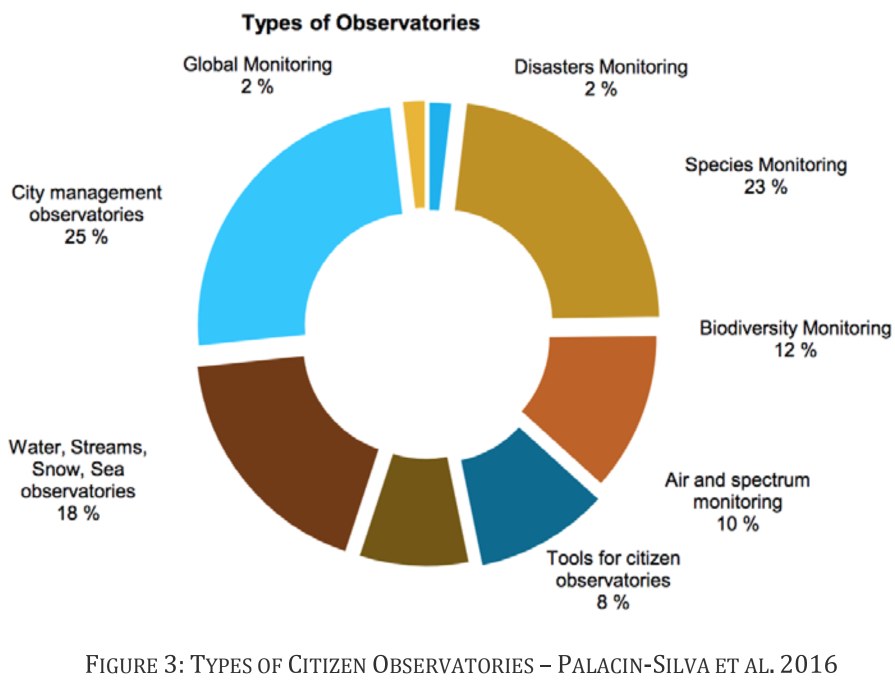


FIGURE 3: TYPES OF CITIZEN OBSERVATORIES – PALACIN-SILVA ET AL. 2016

[21] Wehn, U, and Velzeboer, L. (2018) CoP1 - Co-designing citizen observatories and engaging citizens - Inception Report. July 2018; and, CoP2 - Impact and value of COs for governance - Inception Report. July 2018.

[22] Palacin-Silva et al. 2016

[23] Palacin-Silva, M. and Porras, J. (2018) Shut up and take my environmental data! A study on ICT enabled citizen science practices, participation approaches and challenges. EPiC Series in Computing, Volume 52, 2018, Pages 270–288. ICT4S2018. 5th International Conference on Information and Communication Technology for Sustainability.

These eight categories are defined as follows (with examples taken from the presentation of this research at the 5th International Conference on Information and Communication Technology for Sustainability in Toronto[24]):

1. **“City Management -** Grouped observatories that support decision makers managing city’s issues such as: transportation, bicycle routes, land usage, energy consumption, surroundings classification, environmental conditions, traffic and parking monitoring, citizen needs and perceptions[25]. (E.g. FixMyStreet, SeeClickFix, VizWiz, Waze, CiclePhilly[26])

2. **Species Monitoring** - Involving single species monitoring projects– such as insects, bats, birds, butterflies, sea species, and game animals

3. **Water, streams, snow, sea** - Observatories that are collecting data about water quality, precipitation, streams, lakes, snow, ice and sea environments (E.g. CURA H20, Järviwiki, Brooklying Atlantis, Lakewatch, CoCoRaHS)

4. **Biodiversity monitoring** - Observatories that focus on monitoring biodiversity; flora, forests, mountains, biosphere and trees. (E.g. Plant Watch, Leaf Watch, iNature, Mountain Watch)

5. **Air and spectrum monitoring -** Observatories that gather data about air quality, noise, sounds, and radiation, especially in cities. (E.g. Common Sense, SafeCast, Noise Tube, CitiSense, Bucket Brigades)

6. **Tools for creating monitoring projects -** Involving tools that are useful for creation or integration of citizen observatories, such as: configurable citizen observatories (plug-and-play tools), image classification components and sensor-monitoring components. (E.g. Glassnost, Ushahidi, CitSci, Public Lab)

7. **Global monitoring -** Astronomy and climate change observatories that monitor global trends (E.g. Galaxy Zoo, Spring Watch, GLOBE at Night)

8. **Disaster Monitoring -** Observatories that are looking at earthquake monitoring and early detection.[27] (E.g. iShake, Did you feel it?[28])”

For the purposes of describing the short-list of COs, we have created the template shown in Appendix 1 that includes the field “Domain of Application”, for which we have drawn on Palacin-Silva’s 8 Domains of Application described above.

To those 8 domains, we have made one alteration - splitting ‘Land use’ out from inside ‘City Management’ to create the new category of ‘Land Management’ in order to cover areas such as land use, land cover, and deforestation as follows:

9. **Land-use monitoring -** Dealing with issues of land use, land cover, and change in land use or land cover, in both rural and urban settings.

[24] Palacin-Silva and Porras 2018
[25] Palacin-Silva et al. 2016
[26] Palacin-Silva and Porras 2018
[27] Palacin-Silva et al. 2016
[28] Palacin-Silva and Porras 2018

In their review of 10 years of literature describing community-based environmental monitoring initiatives, Conrad and Hilchey (2011)[29] noted that these initiatives have engaged both the resource sector (often referred to as commodity-based monitoring; e.g., the resource fishery) and the non-resource sector (often referred to as non-commodity-based monitoring; e.g., recreational fishery).

We therefore also add 'Commodity-based monitoring' as a 10th domain.

10. **"Commodity-based monitoring** - Dealing with issues of economic (as well as social and environmental) importance. Examples include monitoring of fisheries and forestry activities . Historically, commodity-based CBM has focused on economic issues, but in more recent years, the focus has shifted to include social and ecological outcomes as well"[30].

4.3.2 Wiggins & Crowston's 5 Types (+ the CAISE 3 Models of PPSR)

Wiggins & Crowston (2011)[31] developed a typology of public participation in research specifically for Citizen Science projects, in order to "*generate a more comprehensive description of the landscape of citizen science by examining common characteristics of projects, grouping similar projects that share necessary conditions for successful research employing this mode of production.*"

To do so, they started by reviewing existing typologies in the literature, aligned them against the different steps of scientific research in which the public can be engaged, and mapped those against the three models for Public Participation in Scientific Research (PPSR) defined in the 2009 CAISE Inquiry Group report 'Public Participation in Scientific Research: Defining the Field and Assessing Its Potential for Informal Science Education'[32], namely:

1. **"Contributory projects,** which are generally designed by scientists and for which members of the public primarily contribute data,
2. **Collaborative projects,** which are generally designed by scientists and for which members of the public contribute data but also may help to refine project design, analyze data, or disseminate findings, and
3. **Co-created projects**, which are designed by scientists and members of the public working together and for which at least some of the public participants are actively involved in most or all steps of the scientific process".[33]

The result of this exercise is shown in Table 4 below.

[29]Conrad, C. C., & Hilchey, K. G. (2011). A review of citizen science and community-based environmental monitoring: issues and opportunities. Environmental monitoring and assessment, 176(1-4), 273-291.
[30] Conrad & Hilchey 2011
[31] Wiggins, A., & Crowston, K. (2011, January). From conservation to crowdsourcing: A typology of citizen science. In System Sciences (HICSS), 2011 44th Hawaii international conference on (pp. 1-10). IEEE.
[32] Bonney, R., Ballard, H., Jordan, R., McCallie, E., Phillips, T., Shirk, J., and Wilderman, C. C. 2009. Public Participation in Scientific Research: Defining the Field and Assessing Its Potential for Informal Science Education. A CAISE Inquiry Group Report. Washington, D.C.: Center for Advancement of Informal Science Education (CAISE).
[33] Bonney et al. 2009

TABLE 4: VOLUNTEER INVOLVEMENT IN ENVIRONMENTAL SCIENCE TYPOLOGIES - WIGGINS & CROWSTON 2011

Stage of Inquiry	Cooper et al.	Wilderman	Bonney et al.	*Contributory*	*Collaborative*	*Co-created*
Define question	✓	✓	✓			X
Gather information			✓			X
Develop hypotheses			✓			X
Design study	✓	✓	✓		(X)	X
Data collection	✓	✓	✓	X	X	X
Analyze samples		✓	✓		X	X
Analyze data	✓		✓	(X)	X	X
Interpret data	✓	✓	✓		(X)	X
Draw conclusions	✓		✓		(X)	X
Disseminate results			✓	(X)	(X)	X
Discuss results & ask new questions			✓			X

VOLUNTEER INVOLVEMENT IN ENVIRONMENTAL SCIENCE TYPOLOGIES, WITH DEFINITIONS OF PARTICIPATORY SCIENCE MODELS. ✓= INCLUDED IN MODEL; X = PUBLIC INCLUDED; (X) = PUBLIC SOMETIMES INCLUDED.

Building and expanding on this work to develop a typology more focused on project goals and the uses of technology, Wiggins and Crowston examined a variety of project characteristics across 32 projects and then clustered them to identify five mutually exclusive and exhaustive types of projects:

1. **"Action -** Action-oriented citizen science projects encourage participant intervention in local concerns, using scientific research as a tool to support civic agendas. They are most commonly grassroots or "bottom-up", are not conceived or planned by scientists, and usually involve long-term engagement in local environmental concerns.
2. **Conservation -** Conservation projects support stewardship and natural resource management goals, primarily in the area of ecology; they engage citizens as a matter of practicality and outreach, and they tend to be regional in scope.
3. **Investigation -** Investigation projects are focused on scientific research goals requiring data collection from the physical environment. Education is frequently a strongly valued but unstated purpose, and task structures often support ongoing learning. These projects range from regional to international in scope, and can achieve very large scales of participation.
4. **Virtual** - Science-oriented Virtual projects are ICT-mediated with no physical elements whatsoever, they are formed through top-down organizing by academics, and most projects' affiliations are exclusively academic.
5. **Education -** Education projects make education and outreach their primary goals, with relevant aspects of place. They can be split into those focusing on informal versus formal learning opportunities, and are sometimes explicitly designed to permit cumulative learning experiences."[34]

Our own template for describing the short-list of COs, thus contains the field "Type of CO" to capture the Wiggens & Crowston typology, and the field 'Model of CO' drawing on the 3 Models of PPSR from the CAISE Report.

[34] Wiggins, & Crowston 2011

4.3.3 Haklay's 3 Policy Dimensions

Haklay's 2015 report 'Citizen Science and Policy: A European Perspective'[35] for the Woodrow Wilson Centre's Commons Lab, charts three dimensions of the intersection of citizen science and policy:

1. **"The level of geography:**
    a. Local community - (e.g., neighborhood scale), where local issues are frequently the motivation for citizen science activities,
    b. City level - where activities are driven by coordination and collaboration between different groups,
    c. Regional level - where coordination effort becomes more formalized
    d. State/Country
    e. Continental
2. **Policy application areas:**
    a. environmental monitoring and environmental decision making,
    b. agriculture and food,
    c. urban planning and cities,
    d. health and medical research,
    e. humanitarian support and development aid,
    f. science awareness, and support of scientific efforts.
3. **Level of engagement and the type of citizen science activity**
    a. **Passive Sensing** - relies on participants providing a resource that they own (e.g., their phone or space in their backyard) for automatic sensing. The information that is collected through these sensors is then used by scientists for analysis

    b. **Volunteer Computing** - a method in which participants share their unused computing resources, on their personal computer, tablet, or smartphone, and allow scientists to run complex computer models when the device is not in use.

    c. **Volunteer Thinking** - participants contribute their ability to recognize patterns or analyze information that will then be used in a scientific project. Commonly, the analysis task is fairly standardized, making it easy to aggregate and compare results from different participants

    d. **Environmental and Ecological Observation** - focuses on monitoring environmental pollution or observations of flora and fauna

    e. **Participatory Sensing** - gives the participant more roles and control over the process. While many environmental and ecological observations follow data collection protocols that were designed by scientists, in participatory sensing the process is more distributed and emphasizes the active involvement of the participants in setting what will be collected and analyzed.

    f. **Civic / Community science -** also known as bottom-up science, is initiated and driven by a group of participants who identify a problem that is a concern for them and address it using scientific methods and tools. Within this type of activity, the problem formation, data

[35] Haklay, M. Citizen Science and Policy: A European Perspective. Washington, DC: Woodrow Wilson International Center for Scholars, 2015

> collection, and analysis are often carried out by community members or in collaboration with scientists or established laboratories."[36]

From this understanding of the policy interface with Citizen Science, we have introduced three fields to the template, namely 'Geographic Level', 'Policy Application Areas', and 'Level of Participation'.

4.3.4 Liu's 6 Properties

In order to develop a conceptual approach to defining and assessing COs in terms of their environmental governance, Liu et al (2014) selected a short list of nine active COs to review, focusing on six properties that they believe determine the potential of the programmes to support informed decision-making:

1. "The aim / purpose of each programme,
2. its geographic scope,
3. project duration,
4. target groups,
5. monitoring parameters, and
6. data collection and interpretation, visualization and information dissemination technologies." [37]

Liu et al (2014) further define three categories into which CO Programmes can be classified:

A. "International programmes whose objectives are to develop Citizens' Observatories using innovative earth observation technologies (air, water, odour, biodiversity, etc.), e.g., CITI-SENSE, WeSenseIt, COBWEB, Citclops, Omniscientis.
B. International programmes whose objectives focus on enabling greater access to and sharing of environmental and societal data, e.g., Eye on Earth.
C. National and/or international programmes whose objectives are on creating community-based environmental monitoring in varying environmental and social contexts towards the goal of ecosystem, biodiversity and environmental quality protection, e.g., the Waterkeeper Alliance programmes, The Big Butterfly Count, Citi-Sense-MOB."[38]

Each of these 6 properties has been incorporated as a unique field into the template for describing COs (see Appendix 1), plus an additional field called "Nature of the Programme", which draws on the three CO Programme classifications named above.

4.3.5 Wehn's 9 Dimensions

In their paper '*Participation in flood risk management and the potential of citizen observatories: A governance analysis*', Wehn et al. (2015)[39] developed a framework to undertake a comparative analysis across three case studies, for which they defined nine dimensions that can be used to describe COs, as shown in Table 5 below.

[36] Haklay, M., 2015. Citizen Science and Policy: a European Perspective. The Woodrow Wilson Center, Commons Lab, Washington, USA.

[37] Liu et al. 2014

[38] Liu et al. 2014

[39] Wehn, U.; Rusca, M.; Evers, J.; Lanfranchi, V. Participation in flood risk management and the potential of citizen observatories: A governance analysis. Environ. Sci. Pol. 2015, 48, 225–236.

TABLE 5: DIMENSIONS OF CITIZEN OBSERVATORIES - WEHN ET AL. 2015

Dimensions	Range
Sensors and transmission	Physical sensor ↔ social sensor
Stakeholders	Authorities ↔ citizens
Area of application	Physical environment ↔ human behaviour
Purpose of citizen observatory	Protect environment ↔ strengthen governance
System integration	Stand-alone ↔ integrated
Measurement	Objective ↔ subjective
Implementation	Bottom up ↔ top-down
Communications paradigm	Uni-directional ↔ interactive
Citizen participation in governance processes	Implicit data provision ↔ technical expertise Individual education ↔ direct authority

Each of these 9 dimensions have also been incorporated as unique field into the template for describing COs (see Appendix 1), with indicators along the ranges described above.

4.3.6 Conrad & Hilchey's 3+3 Types of Monitoring Activities

The range of observation or monitoring activity can vary widely between COs. In their review of citizen science and community-based environmental monitoring projects, Conrad & Hilchey (2011)[40] identify three different types of assessments of ecosystems:

1. "Status assessment (i.e., population monitoring),
2. Impact assessment (i.e., effect of pollution), or
3. Adaptive management (i.e., managing based on monitoring);

and three different aspects of the ecosystem that are being monitored:

1. Ecosystem composition (i.e., indicator species or species at risk),
2. Structure (i.e., biodiversity analysis, keystone species, predator–prey relations), or
3. Processes (i.e., linking species with environment, nutrient cycling, etc.). "[41]

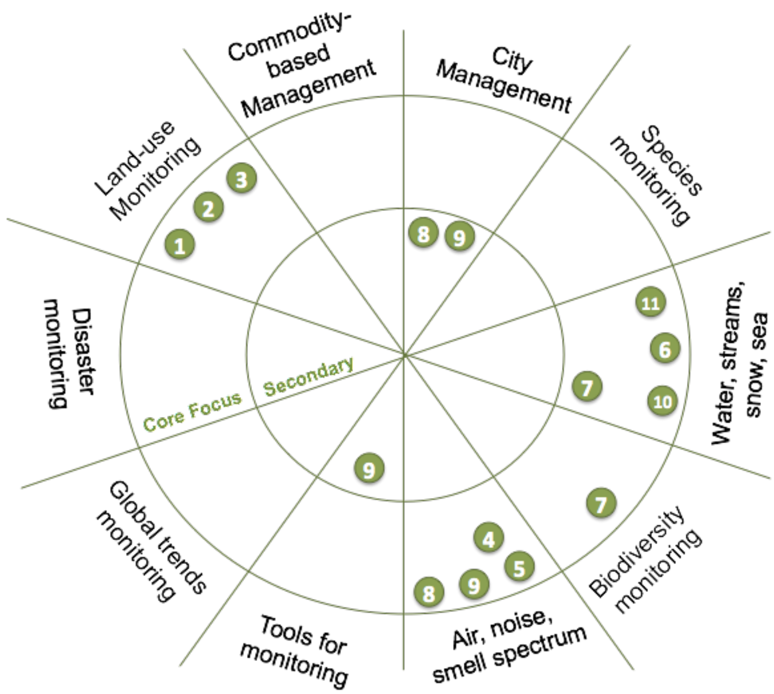
These are captured in our template, with the field 'Types of Monitoring Activities'.

4.4 The WeObserve Knowledge Hub Overview of Citizen Observatories in Europe

Having identified a number of key frameworks for describing and categorising our short list of COs, as captured in the Project Description Template shared in Appendix 1, these will now be used to create project descriptions of the selected COs listed in Table 1, which will be shared online on the newly launched WeObserve Knowledge Hub at www.weobserve.eu, along with visualisations of the landscape of COs by descriptive category.

[40] Conrad, C. C., & Hilchey, K. G. (2011). A review of citizen science and community-based environmental monitoring: issues and opportunities. Environmental monitoring and assessment, 176(1-4), 273-291.
[41] Conrad and Hilchey 2011

For example, the domains of application represented by the COs described in this report are illustrated in Figure 4 below, shown as per their primary and secondary areas of focus.



1. Ground Truth 2.0
2. GROW
3. LandSense
4. Scent
5. D-Noses
6. Monocle
7. COBWEB
8. Omniscientis
9. Citi-Sense
10. WeSenseIt
11. Citiclops

FIGURE 4: SHORT-LISTED CITIZEN OBSERVATORIES BY DOMAIN OF APPLICATION

One of the main purposes of the WeObserve Knowledge Hub website is to serve as the repository for resources developed by WeObserve, such as the description of COs, a 'Cookbook' collating best practice throughout the CO lifecycle, a MOOC for CO practitioners and those wishing to launch a CO, and other best practice guidelines arising from the CoPs.

5 Benchmarking the Citizen Observatories

Once we have categorised and described the short-list of COs in a consistent fashion, we wish to benchmark the selected COs in a way that can easily be visually compared.

For this we turn to the Benchmarking Framework developed by Gharesifard et al. (2017) - a conceptual framework that enables a systematic review of the features and functioning of COs.

In their paper building on the findings of Wehn et al. (2015) and Gharesifard & Wehn (2016)[42] in order to develop a framework for benchmarking COs in the context of online amateur weather networks,

[42] Gharesifard, M. and Wehn, U. (2016). To share or not to share: drivers and barriers for sharing data via online amateur weather networks. J. Hydrol., 535 (2016), pp. 181-190, 10.1016/j.jhydrol.2016.01.036 April

Gharesifard et al. (2017)[43] summarised a number of previous studies that identified and defined 'dimensions' for e-participation (including Wehn's 9 Dimensions and Haklay's 3 Policy Dimensions described above), with the objective of introducing "*a conceptual framework that enables a systematic review of the features and functioning of these expanding networks.*"[44]

The Gharesifard et al (2017) conceptual framework covers eight key dimensions, each of which consists of a range of relevant classifications that are either directly comparable for different platforms or need qualitative scores to make the comparison possible, as shown in Table 6 below.

TABLE 6: THE ANGE, SCORES AND SOURCES OF THE DIMENSIONS OF ONLINE AMATEUR WEATHER NETWORKS - GHARESIFARD ET AL. 2017

Dimension	Range	Score	Source
(1) Geographic scope & no. of stations	Local (No. of participants)	Directly comparable	Geography (Haklay, 2015) Geographic scope/Level of engagement (Roy et al., 2012)[45] Accessibility (Macintosh, 2004)[46]
	National (No. of participants)		
	Regional (No. of participants)		
	Global (No. of participants)		
(2) Type of Participants	Netizens	Directly comparable	Participants (Wehn et al., 2015) Actors (Macintosh, 2004)
	Citizen scientists		
	Volunteers		
	(Scientific) experts		
	Private sector		
	Non-Governmental Organizations (NGOs)		
	Emergency services		
	Local authorities		
	National organizations		
	Regional organizations		
	International organizations		

[43] Gharesifard, M., Wehn, U., van der Zaag, P. (2017). Towards benchmarking citizen observatories: features and functioning of online amateur weather networks. J. Environ. Manag. http://dx.doi.org/10.1016/j.jenvman.2017.02.003
[44] Gharesifard et al. (2017)
[45] Roy, H., Pocock, M., Preston, C., Roy, D., Savage, J., Tweddle, J., Robinson, L., 2012. Understanding Citizen Science and Environmental Monitoring: Final Report on Behalf of UK-EOF. NERC Centre for Ecology & Hydrology and Natural History Museum.
[46] Macintosh, A., Coleman, S., 2003. Promise and problems of e-democracy: challenges of online citizen engagement. Organ. Econ. Co-oper. Dev. http://dx.doi.org/10.1787/9789264019492-en.

(3) Network Establishment Mechanism	Bottom-up	Directly comparable	Implementation mechanism (Ciravegna et al., 2013; Wehn et al., 2015b)[47]
	Commerce driven		
	Top-down		
(4) Revenue stream to sustain the network	Government sponsorship	Directly comparable	Resources and promotion (Macintosh, 2004) Revenue streams (Osterwalder and Pigneur, 2010)
	Data / information usage		
	Subscription fee		
	Asset sale		
	Advertising		
	Licensing		
	Donation		
(5) Communication paradigm	Uni-directional	Directly comparable	Communication paradigms (Ciravegna et al., 2013)
	Bi-directional		
	Interactive		
(6) Effort required by data sharers	Registration efforts	L / M / H	Perceived behavioral control factors (Gharesifard, 2015)[48] Degree of mass participation attributes (Roy et al., 2012)
	Monetary investments	L / M / H	
	Knowledge requirements	L / M / H	
(7) Support offered by platform providers	Diversity of supported sensor types	L / M / H	Perceived behavioral control factors (Gharesifard, 2015) Support provided by platform managers (Roy et al., 2012)
	Supporting material	Y / N	
	Usability of the web-platforms	L / M / H	
	Usability of the apps	L / M / H	
	Stated description of the apps	Y / N	
(8) Data accessibility, availability and quality	Level of access to data for general public	L / M / H	Data accessibility, availability and quality (Roy et al., 2012)
	Diversity of accessible weather parameters	L / M / H	
	Metadata quality and accessibility	L / M / H	
	Data quality control	L / M / H	

[47] Wehn, U., McCarthy, S., Lanfranchi, V., Tapsell, S.M., 2015a. Citizen observatories as facilitators of change in water governance? Experiences from three European cases. Environ. Eng. Manag. J. 14 (9), 2073e2086.

[48] Gharesifard, M., 2015. Mapping the Behavioural Determinants of ICT-based Citizen Participation in Water Management; Case Studies of Sharing Personally collected Weather Data via Web-platforms in the Netherlands, UK and Italy. MSc thesis. UNESCO-IHE Institute for Water Education, Delft, The Netherlands (WM-WRM.15e11).

The visualisation of this conceptual framework and comparative analysis as applied to the six online amateur weather networks for which Gharesifard et al gathered publicly available data and supplementary data via interviews, is shown in Figure 5 below.

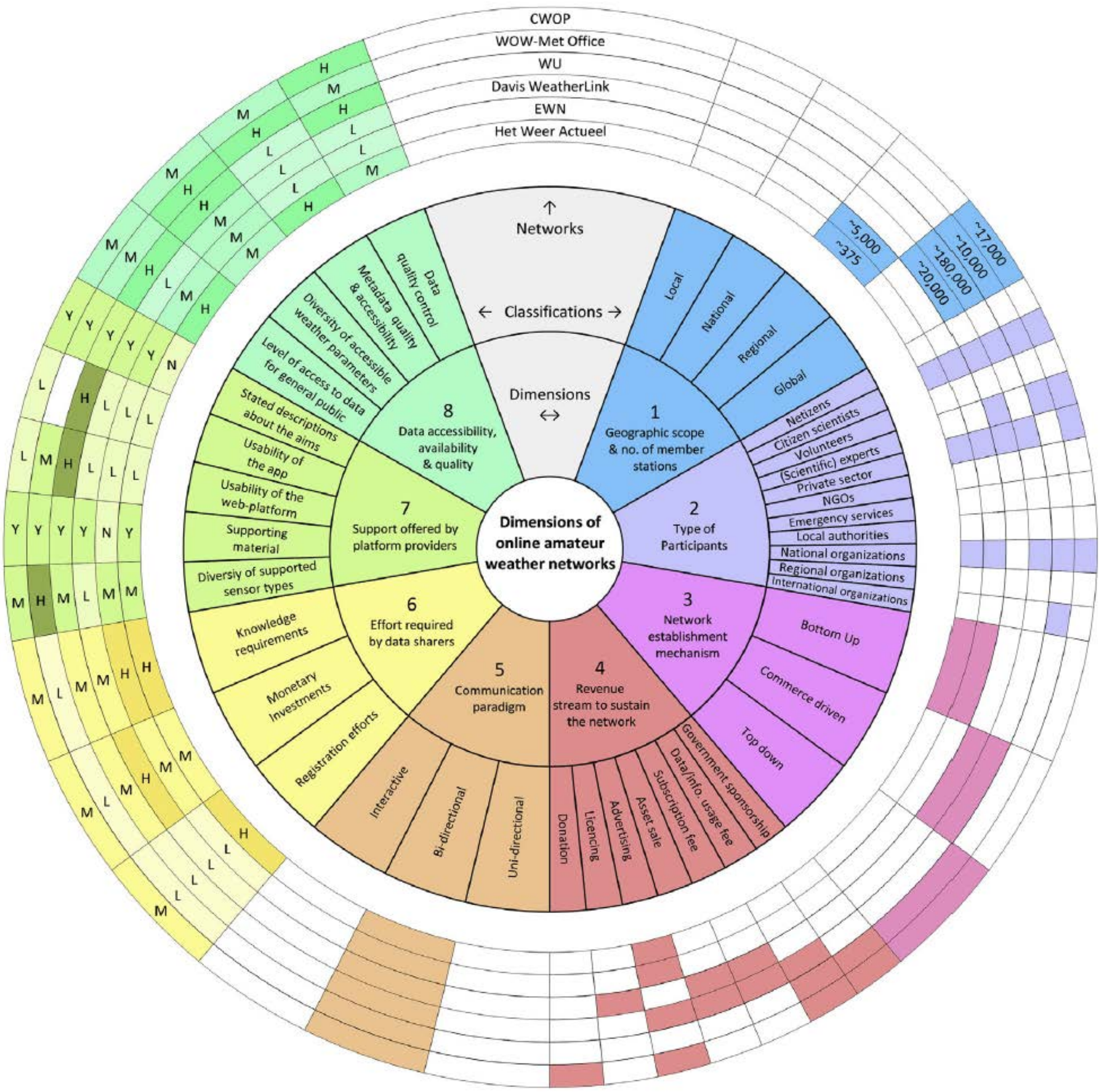


FIGURE 5: SUMMARY OF THE ASSESSMENT OF SIX ONLINE AMATEUR WEATHER NETWORKS. COLORED CELLS IN DIMENSION 1 TO 5 INDICATE THE APPLICABLE RANGE FOR EACH NETWORK. DIMENSIONS 6-8 USE A QUALITATIVE SCORING SYSTEM WHERE L = LOW (INCL. NONE), M = MODERATE, H = HIGH, Y = YES, AND N = NO.

As we develop visualisations to illustrate the Landscape of COs in Europe for the newly launched WeObserve Knowledge Hub at www.weobserve.eu, we will also adapt this Framework to more closely fit the particularities of those projects. (For example - all of the FP7 and H2020 funded COs are by definition top-down in terms of establishment of the network, and none of them (in so far as we have uncovered to date) have an independent revenue stream apart from the grant-funding.) The visual benchmark of COs will then be shared online, alongside the project descriptions.

6 Next Steps - Assessing and Evaluating the Landscape of COs in Europe

The '**D2.1 - Frameworks Report'** and the resulting project descriptions and visualisations shared online form the first phase of a dynamic exercise across the first two years of the WeObserve project.

Having completed our review of the literature to consolidate the numerous definitions of a CO, and to select a range of frameworks for the purpose of describing and categorising our selected short-list of COs, as well as a framework for benchmarking those COs, we now embark on filling in those details through a combination of desk research and interviews with project consortium members who are also members of the WeObserve network of partners and supporters. These will be shared online at www.weobserve.eu.

The next phase of investigation into the Landscape of COs in Europe will be to undertake a deeper analysis of the same short-list of selected COs, based on a number of frameworks that have been developed for that purpose. Many of these frameworks have been identified during the review of the literature undertaken at the outset of the WeObserve project, and are described in Appendix 2 and Appendix 3 below.

Finally, we will undertake a more detailed mapping exercise of the CO landscape, to identify a larger number of organisations and stakeholders who are in some way involved in supporting CO initiatives. This mapping will be undertaken through consultation with the WeObserve partners and partner-COs, through workshops with a wider range of stakeholders via the WeObserve CoPs, and also by conducting database and web searches.

In doing so, we will expand upon the selected short list of COs to capture a wider range of top-down and bottom-up projects across Europe, including those that do not necessarily identify themselves as such, but do meet the definition of a CO. For example, through the systematic literature review, Palacin-Silva et al. (2016) identified 40 citizen observatories in Europe, as shown in Figure 6 below.

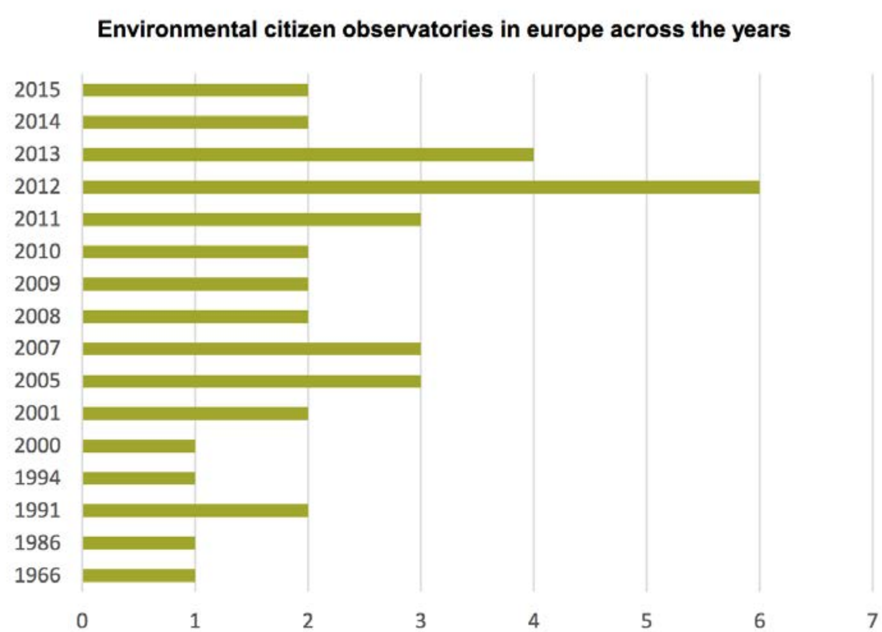


FIGURE 6: CITIZEN OBSERVATORIES IN EUROPE BY YEARS OF START - PALACIN-SILVA 2016

These investigations will culminate in the final report '**D2.4 - Landscape of COs in Europe'**, to be completed in Month 24 of the WeObserve project.

6.1 Methodology

In this next phase, we embark on the assessment and evaluation of the COs, including an expansion of the list of COs to be investigated.

In Appendix 2 - Frameworks for Assessing and Analysing Citizen Observatories below we list a number of frameworks which have been identified for the purpose of ***assessment*** of the COs - by which we mean the process of collecting, reviewing and using data, for the purpose of developing best practice, identifying areas for improvement, and improving the processes involved. This can be seen as an ongoing formative and interactive process between CO practitioners and stakeholders.

In Appendix 3 - Frameworks for Measuring Success and Impact below we list a number of frameworks which have been identified for the purpose of ***evaluation*** of the COs - by which we mean a set of standards by which the success and impact of COs can be measured, for the purpose of judging the outcomes of CO initiatives. This can be seen as a more formal summative process between CO practitioners and stakeholders in order to draw conclusions and guide future efforts.

In applying these frameworks we will undertake at least 5 focus groups to be organised in parallel with planned WeObserve events.

Additionally, approximately 20 in-depth interviews with key selected stakeholders will provide detailed quantitative and qualitative information on their understanding of CO best practice, as well as the major issues and challenges facing the successful implementation and running of COs.

Alongside a deeper investigation of the selected COs, these face-to-face meetings will also aim to understand the nature of connections and interactions between the previous and current CO networks, to explore the potential for cooperation, and to design defragmentation actions as key ingredients for improved coordination and knowledge sharing among (emerging) initiatives and relevant communities. Frameworks for mapping these connections and interactions are still to be identified.

Where possible, we will also draw on the outcomes of the DG-ENV project to inventorise Citizen Science projects in the EU that have an impact on environmental policy, and the work of the Citizen Science COST Action WG 4: *Concepts and Methodological Framework for Mapping Stakeholders in CS.* Other inventories of Citizen Observatories and Citizen Science Projects that have appeared in the literature, and may thus be relevant, are logged in Appendix 4.

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Vallejo, B., & Wehn, U. (2016). Capacity Development Evaluation: The Challenge of the Results Agenda and Measuring Return on Investment in the Global South. *World Development*, *79*, 1-13. doi:http://dx.doi.org/10.1016/j.worlddev.2015.10.044

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Wehn, U., Rusca, M., Evers, J., & Lanfranchi, V. (2015b). Participation in flood risk management and the potential of citizen observatories: A governance analysis. *Environmental Science & Policy*, *48*(0), 225-236. doi:http://dx.doi.org/10.1016/j.envsci.2014.12.017

Wehn, U, and Velzeboer, L. (2018) CoP1 - Co-designing citizen observatories and engaging citizens - Inception Report. July 2018; and, CoP2 - Impact and value of COs for governance - Inception Report. July 2018.

Wiggins, A., & Crowston, K. (2011, January). From conservation to crowdsourcing: A typology of citizen science. In System Sciences (HICSS), 2011 44th Hawaii international conference on (pp. 1-10). IEEE.

World Bank Group. (2016). Evaluating Digital Citizen Engagement. Washington, DC. © World Bank. https://openknowledge.worldbank.org/handle/10986/23752.

APPENDIX 1 - Project Description Template - COBWEB Example

PROJECT NAME

OVERVIEW	
Overall Aim of the CO	
Purpose of CO[2]	Protect environment strengthen governance
Type of CO[6]	
Model of CO[7]	
Case Study Areas	
Tech Focus	
Domain of Application[3]	
Area of Application[2]	Physical environment ↔ human behaviour
Policy Application Area[4]	
PROJECT DETAILS	
Coordinator	
Consortium Partners	
Project Website	
CORDIS page	
Timeline	

FP7 Topic	
PROJECT DESCRIPTION	
Nature of the Programme	International with innovative earth observation tech International with greater access & sharing of environmental & societal data National / International and community based
Geographic Level[4]	
Locations[1]	
Target Groups [1]	
Stakeholders[2]	Authorities ↔ citizens
Related Communities & Enabling Environment	
Continuity	
Monitoring Parameters[1]	
Types of Monitoring Activities [5]	

Level of Participation[4]	
Number of Participants	
Data collection, communication and visualization[1]	Data collection: Data communication: Data visualization:
Sensors and transmission[2]	Physical sensor ↔ social sensor
Type of Measurement[2]	Objective ↔ subjective
Number of Observations submitted	
Open Source, Standards & Interoperability	
System Integration[2]	Stand-alone ↔ integrated
Implementation	Bottom up ↔ top-down

[1]As reported in Liu et al 2014, Additional File 1 - 'Liu's 6 Properties'
[2]'Wehn's 9 Dimensions'
[3]Pallacin-Silva's 8 Domains of Application + 2
[4] Haklay's 3 Policy Dimensions
[5] Conrad & Hilchey's 3 + 3 Monitoring Activities
[6] Wiggins & Crowston's 5 Types
[7] the CAISE 3 Models of PPSR

APPENDIX 2 - Frameworks for Assessing and Analysing Citizen Observatories

The central purpose of the WP2 task, into which these Landscape reports fall, is to explore and report on the extent of CO initiatives in Europe, their relevant communities, and the networks that have formed among them. This involves:

> (a) understanding how and why they originated, how they function in terms of structure, governance, means, activities, and events, and the nature of the networks and associations with which they interact; and
>
> (b) surveying the interactions in a multi-stakeholder approach to better comprehend their connections and relations.

The next phase of investigation into the Landscape of COs in Europe will be to undertake a deeper analysis of the same short-list of selected COs, based on a number of frameworks that have been developed for that purpose. Many of the frameworks that are well suited to the purpose of assessing and analysing the COs have been identified during the review of the literature undertaken at the outset of the WeObserve project, and are described in this Appendix.

The frameworks that we have identified so far that are well suited for the purpose of evaluation are contained in Appendix 3 - Frameworks for Measuring Success and Impact below.

For our purposes, we differentiate between assessment and evaluation in the following way:

1. by ***assessment*** we mean the process of collecting, reviewing and using data, for the purpose of developing best practice, identifying areas for improvement, and improving the processes involved. This can be seen as an ongoing formative and interactive process between CO practitioners and stakeholders.
2. by ***evaluation*** we mean a set of standards by which the success and impact of COs can be measured, for the purpose of judging the outcomes of CO initiatives. This can be seen as a more formal summative process between CO practitioners and stakeholders in order to draw conclusions and guide future efforts.

In applying these frameworks during the next stage of the project, we will undertake at least 5 focus groups that are likely to be organised in parallel with one of the WP3 events. Additionally, we will undertake approximately 20 in-depth interviews with key selected stakeholders.

The outcomes will be shared in the '**D2.4 - EU Citizen Observatories Landscape Report',** to be completed in Month 24 of the WeObserve project.

Governance Analysis of Participation - Wehn et al. 2015

Building on the 9 Dimensions of COs described above, Wehn et al. (2015)[49] went on to develop a framework for gauging the potential of ICT-enabled citizen observatories for increased citizen participation

[49] Wehn, U., Rusca, M., Evers, J., & Lanfranchi, V. (2015). Participation in flood risk management and the potential of citizen observatories: A governance analysis. Environmental Science & Policy, 48, 225-236. doi:10.1016/j.envsci.2014.12.017

in flood risk management, based on Fung's democracy cube[50] for measuring public participation (see Figure 7 below).

This framework captures three key dimensions: Authority & Power, Participants, and Communication & Decision Mode, and is designed to comparatively measure modes of governance alongside stakeholder participation.[51]

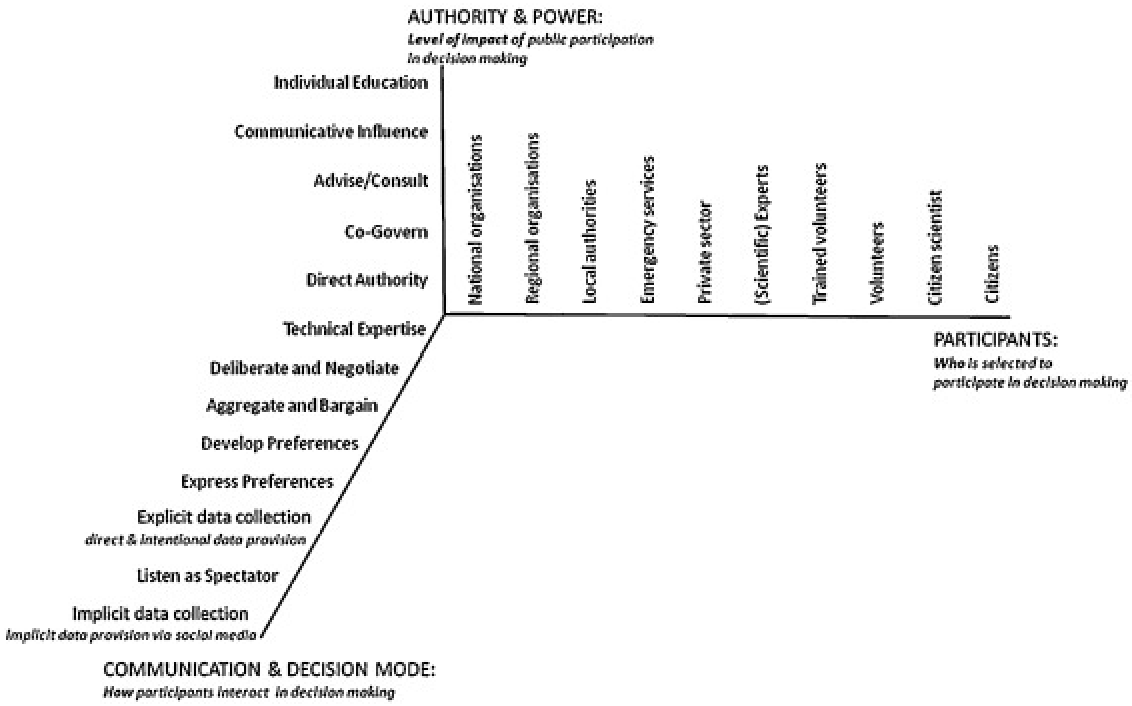


FIGURE 7: CITIZEN PARTICIPATION VIA ICT-ENABLED OBSERVATORIES FRAMEWORK

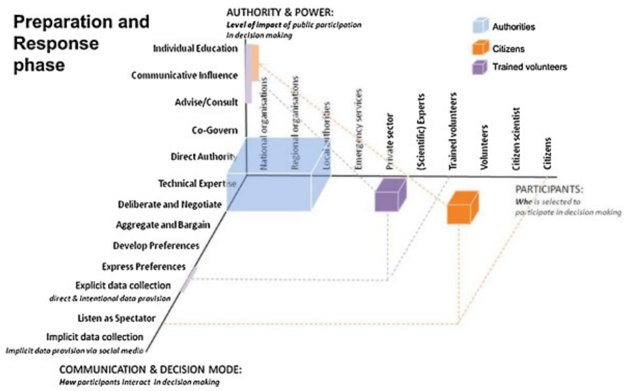
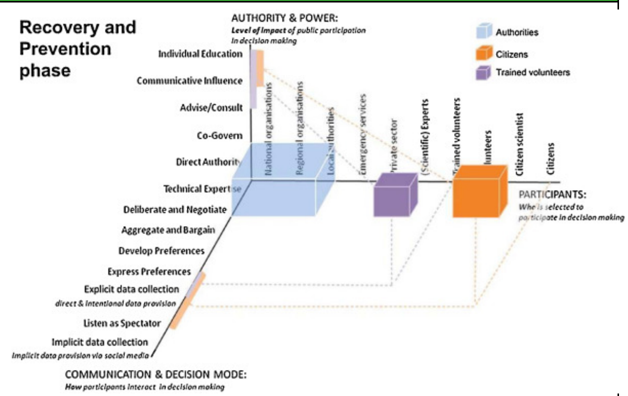
The comparative power of the model is fully utilised when the relevant stakeholder groups are mapped against the axes, across different stages of the project lifecycle, as shown for example in Table 7 below, when used to assess governance models in the Doncaster Case Study of the WeSenseIT project[52].

[50] Archon Fung. Varieties of participation in complex governance. Public Adm. Rev., 66 (2006), pp. 66-75

[51] Wehn et al 2015

[52] Wehn et al 2015

TABLE 7: CITIZEN PARTICIPATION IN DECISION MAKING IN FLOOD RISK MANAGEMENT – DONCASTER UK CASE STUDY - WEHN ET AL. 2015

Preparation & Response Phase	Recovery & Prevention Phase
	
See full image	*See full image*

This framework has the potential to show the authorities' perception of citizen participation and the extent to which authorities expect or have experienced valuable outcomes from citizen participation, the citizens' interest in participating, and the different strategies deployed to make the most of the potential for ICT to support citizen participation.

Where possible, we will gather the data required to apply this framework across a greater range of CO Case Studies for comparative purposes.

Assessing Impact - Gharesifard's Framework for ICT-based Initiatives

At the 2016 Citizen Observatories for Water Management Conference in Vienna, Gharesifard et al. presented a framework for analysing the impact of ICT-based citizen science initiatives, based on 5 different dimensions of COs (Objective, Technology, Participation, Power dynamics, & Results), which they broke out into a series of enquiries for each dimension, as shown in Figure 8 below[53].

In this presentation, Gharesifard et al. propose that an in-depth analysis of these dimensions will "help understand various dynamics such as:

- Motivations to run the initiatives
- Sustainability of the initiatives
- Data accessibility and quality
- Level of transparency"[54]

Although the link is not made in the written presentation between this framework and the proposed outcomes, it does introduce the crucial aspect of measuring the stated objective of the CO against the measurable results of the initiative.

[53] Gharesifard, M., Wehn, U., van der Zaag, P. (2016) A framework for analysing the impact of ICT-based citizen science initiatives. COWM2016 - International Conference on Citizen Observatories for Water Management, Venice, Italy June 2016.
[54] Gharesifard et al 2016

Because this framework is loosely based on World Bank guidance for evaluating digital citizen engagement[55], which is structured around the lenses of Objective, Control, Participation, Technology & Effects, we will turn to that document during our assessment of the short-list of COs.

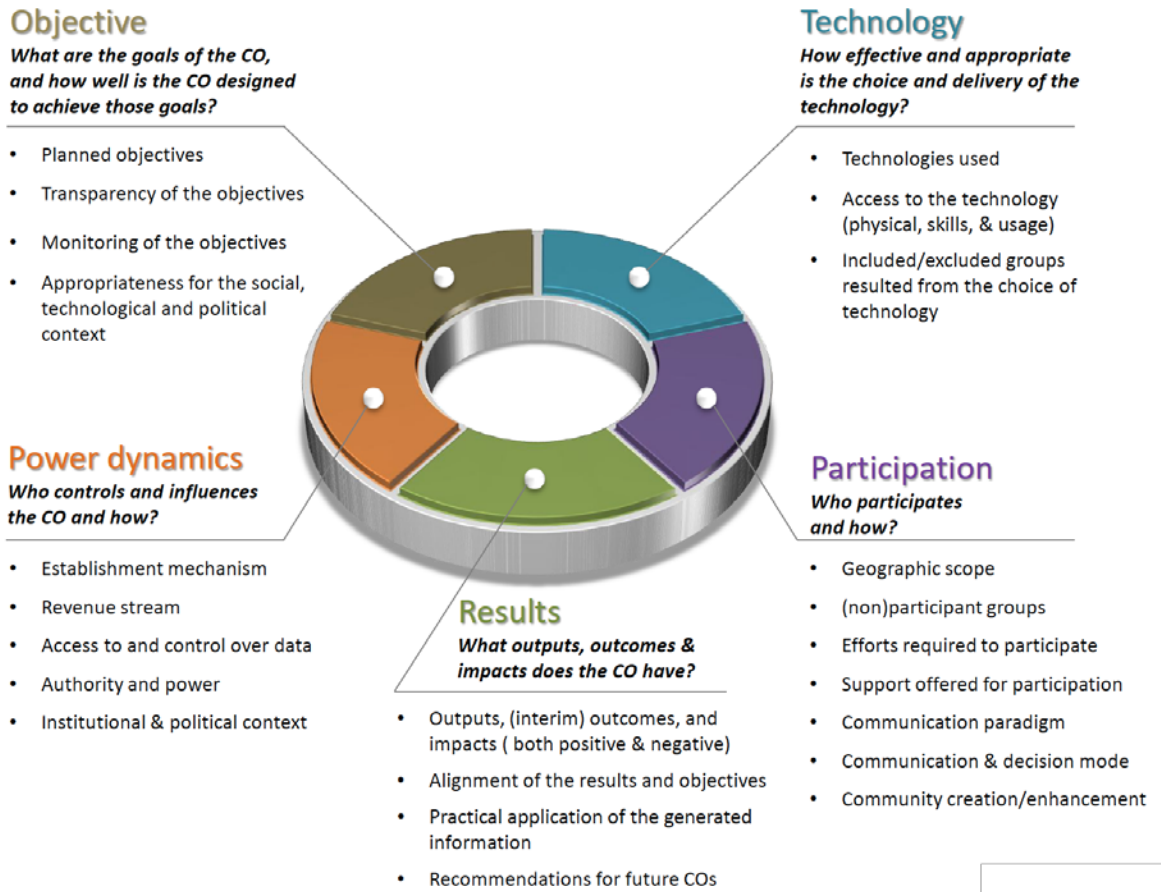


FIGURE 8: CITIZEN PARTICIPATION VIA ICT-ENABLED OBSERVATORIES FRAMEWORK

Assessing Outcomes - Shirk's Framework for Deliberate Design of PPSR Projects

In their paper '*Public Participation in Scientific Research: a Framework for Deliberate Design*'[56], Shirk et al. develop a framework to describe the impact that integrating scientific and public interests in project design have on multiple, integrated goals, and also use the term public participation in scientific research

[55] World Bank Group. (2016). Evaluating Digital Citizen Engagement. Washington, DC. © World Bank. https://openknowledge.worldbank.org/handle/10986/23752.

[56] Shirk JL, Ballard HL, Wilderman CC, Phillips T, Wiggins A, Jordan R, et al. Public Participation in Scientific Research: a Framework for Deliberate Design. Ecol Soc. 2012; 17: 29. doi: 10.5751/ES-04705-170229

(PPSR)[57], which was first established in the CAISE Enquiry Group report on PPSR, to encompass initiatives from diverse fields and traditions, such as citizen science, participatory action research and volunteer biological monitoring.

> "*To have an impact on conservation, PPSR projects generally strive for outcomes that fall into one or more of three main categories: outcomes for research (e.g., scientific findings); outcomes for individual participants (e.g., acquiring new skills or knowledge); and/or outcomes for social–ecological systems (e.g., influencing policies, building community capacity for decision making, taking conservation action).*"[58]

Shirk et al divide PPSR projects into five models based on degree of participation:

1. "**Contractual projects**, where communities ask professional researchers to conduct a specific scientific investigation and report on the results;
2. **Contributory projects**, which are generally designed by scientists and for which members of the public primarily contribute data;
3. **Collaborative projects**, which are generally designed by scientists and for which members of the public contribute data but also help to refine project design, analyze data, and/or disseminate findings;
4. **Co-Created projects**, which are designed by scientists and members of the public working together and for which at least some of the public participants are actively involved in most or all aspects of the research process; and
5. **Collegial contributions**, where non-credentialed individuals conduct research independently with varying degrees of expected recognition by institutionalized science and/or professionals."[59]

Each of these models of participation has at its heart the question "whose interests are being served?", and are represented in the 'Inputs' section of the framework, shown in Figure 8 below. In this illustration, the balance the inputs from both scientific and public interests can be shown by arrows of different sizes, and feedback loops are also indicated by arrows to show that "certain outcomes may reinforce certain interests—and therefore particular design emphases—as initiatives evolve over time." [60]

[57] Bonney, R., Ballard, H., Jordan, R., McCallie, E., Phillips, T., Shirk, J., and Wilderman, C. C. (2009). Public Participation in Scientific Research: Defining the Field and Assessing Its Potential for Informal Science Education. A CAISE Inquiry Group Report. Washington, D.C.: Center for Advancement of Informal Science Education (CAISE)

[58] Shirk et al. 2012

[59] Shirk et al. 2012

[60] Shirk et al. 2012

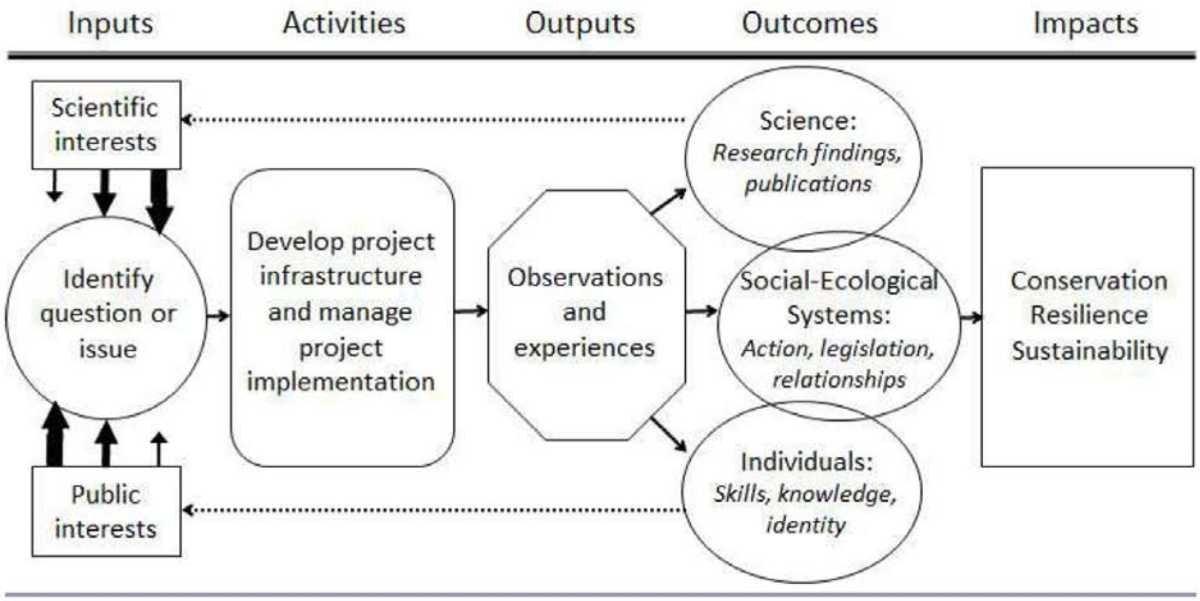


FIGURE 9: FRAMEWORK FOR PUBLIC PARTICIPATION IN SCIENTIFIC RESEARCH PROJECTS - SHIRK ET AL. 2012

In our assessment of the selected COs, we will turn to this model to investigate how well the design of the projects has aligned with the desired outcomes.

Assessing Diversity - Pandya's framework for Engaging Diverse Communities

In exploring why certain groups are historically underrepresented in science, and thus also show low levels of participation in citizen science, Rajul Pandya (2012)[61] has developed a participatory framework for designing citizen-science programs that align with community priorities. He notes that not only is the lack of participation by specific racial, ethnic, or socioeconomic groups inconsistent with a democratic approach to science, but it also affects the quality of the citizen-science projects themselves.

To broaden the reach and impact of citizen science, Pandya recommends the following general framework:

1. Align research and education with community priorities
2. Plan for co-management of the project
3. Engage the community at every step
4. Incorporate multiple kinds of knowledge
5. Disseminate results widely

In COs that explicitly state diversity of outreach as a goal or their initiative, we will turn to this framework to assess the effectiveness of their project design for this purpose, and its outcomes.

[61] Pandya, R. E. (2012). A framework for engaging diverse communities in citizen science in the US. Frontiers in Ecology and the Environment, 10(6), 314-317.

A Science-focused Typology for Citizen Science - Parrish et al 2018

In their pending publication 'Exposing the Science in Citizen Science: Fitness to Purpose and Intentional Design', the goal of Parish et al (2018[62]) is to facilitate both acceptance and use of citizen science by the professional science community, and intentional design of projects with science as a primary objective by presenting a science-focused typology that differentiates projects based on intent and activity.

> *"We generated our schema through an iterative process ... tested against:*
>
> *(1) all projects (unique projects = 80) highlighted as examples in all previous literature proffering a typology or categorization of citizen science (i.e., see references above),*
>
> *(2) the 388 biodiversity citizen science projects collected in the Theobald et al. (2015) meta-analysis,*
>
> *(3) projects managed directly by the authors, and projects associated with and/or analogous to or duplicative of those projects (e.g., all projects focused on beach habitats; projects focused on documenting phenology), and*
>
> *(4) all projects on data collection platforms managed by the authors (e.g., in the Zooniverse). In total, over 500 projects were tested against our typology*[63]"

The resulting typology of citizen science separates projects according to scientific intent and participant activities, as shown in Figure below:

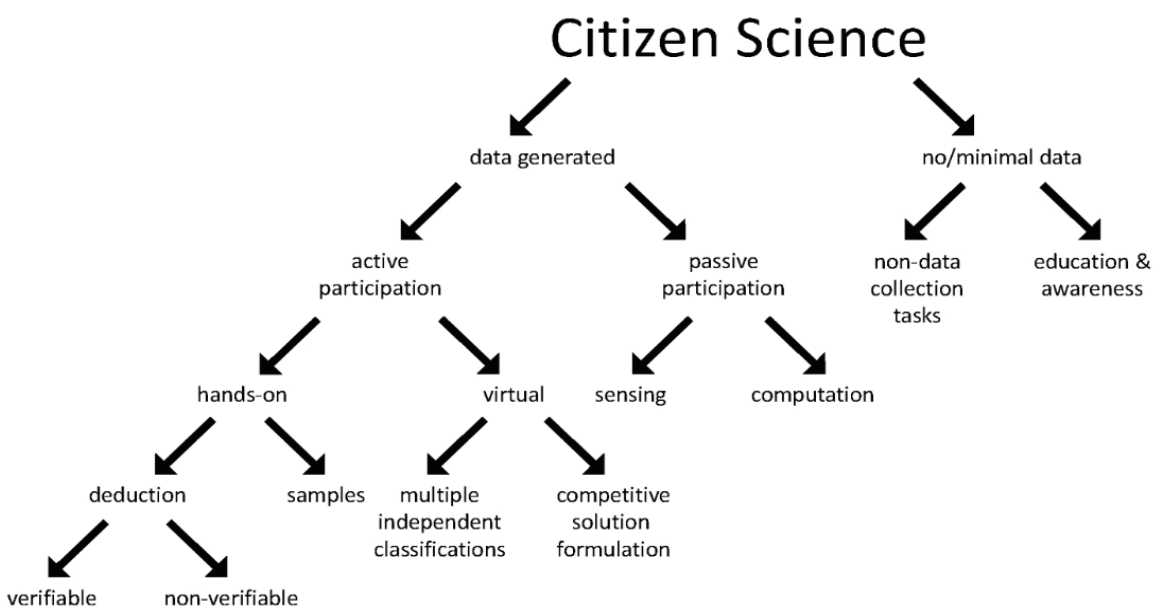


FIGURE 10: A TYPOLOGY OF CITIZEN SCIENCE SEPARATING PROJECTS ACCORDING TO SCIENTIFIC INTENT AND PARTICIPANT ACTIVITIES - PARRISH ET AL. 2018

[62] Parrish, J. K., Burgess, H., Weltzin, J. F., Fortson, L., Wiggins, A., & Simmons, B. (2018). Exposing the Science in Citizen Science: Fitness to Purpose and Intentional Design. Integrative and Comparative Biology, Volume 58, Issue 1, 1 July 2018, Pages 150–160, https://doi.org/10.1093/icb/icy032

[63] Parrish et al. 2018

“We define a science-based typology focused on the degree to which projects deliver the type(s) and quality of data/work needed to produce valid scientific outcomes directly useful in science and natural resource management. Where project intent includes direct contribution to science and the public is actively involved either virtually or hands-on, we examine the measures of quality assurance (methods to increase data quality during the design and implementation phases of a project) and quality control (post hoc methods to increase the quality of scientific outcomes).”

APPENDIX 3 - Frameworks for Measuring Success and Impact

As described in Appendix 2 above, this next phase of investigation into the Landscape of COs in Europe entails a deeper analysis of the short-list of selected COs, for which we have identified a number of suitable frameworks during the review of the literature.

The frameworks which we have identified as being well suited for the purpose of evaluation are contained in this Appendix. For our purposes we have defined ***evaluation*** to mean a set of standards by which the success and impact of COs can be measured, for the purpose of judging the outcomes of CO initiatives. This can be seen as a more formal summative process between CO practitioners and stakeholders in order to draw conclusions and guide future efforts.

Having reviewed a short list of nine active COs at the time of their research, Liu et al identified 5 characteristics that they felt to be vital to the success of a CO:

1. "A CO should involve citizens as active partners in environmental monitoring and decision-making, since this is central for protecting and enhancing our environment;
2. CO-related environmental monitoring should target an array of natural resources and/or a range of environmental components;
3. Generally, the involvement of citizens in CO has multiple purposes, with education and raising public awareness being the most common objectives associated with a CO;
4. There is value in CO as a way to bring community groups together. CO, like other forms of civic engagement, can build social capital within the community, and
5. Evaluation of the effectiveness of a CO as well as of the public involvement in environmental decision-making is generally lacking."[64]

In this section we seek to describe frameworks that can evaluate the degree to which each of these characteristics has been successfully implemented in the CO, with the aim of addressing the last point in particular - introducing more frequent and consistent evaluation of both the effectiveness and the impact of COs across the board.

The outcomes of these evaluations will be shared in the '**D2.4 - EU Citizen Observatories Landscape Report',** to be completed in Month 24 of the WeObserve project.

Evaluating Impact - the CAISE Report Rubix

In their 2009 report, an Inquiry Group supported by the Center for Advancement of Informal Science Education (CAISE)[65] describes how Public Participation in Scientific Research (PPSR), in the context of informal science education, can provide multiple opportunities to increase public science literacy.

In order to do so, the authors investigated ten PPSR projects and developed a rubric to describe, assess, and compare them based on the evaluation framework described in Evaluating Impacts of Informal Science Education Projects (Friedman 2008)[66]. Their rubric is shown in Table 8 below.

---

[64] Liu et al. 2014

[65] Bonney, R., Ballard, H., Jordan, R., McCallie, E., Phillips, T., Shirk, J., and Wilderman, C. C. 2009. Public Participation in Scientific Research: Defining the Field and Assessing Its Potential for Informal Science Education. A CAISE Inquiry Group Report. Washington, D.C.: Center for Advancement of Informal Science Education (CAISE)

[66] Allen, S., Campbell, P. B., Dierking, L. D., Flagg, B. N., Friedman, A. J., Garibay, C., & Ucko, D. A. (2008, February). Framework for evaluating impacts of informal science education projects. In Report from a National Science Foundation Workshop. The National Science Foundation, Division of Research on Learning in Formal and Informal Settings.

TABLE 8: ASSESSMENT RUBRIC FOR DESCRIBING IMPACTS OF PPSR PROJECTS - BONNEY ET AL. 2009

Table 2. Assessment Rubric for Describing Impacts of Public Participation in Scientific Research Projects				
Impact category	Stated goal	Potential indicators	Measured outcomes	Inferred outcomes
Awareness, knowledge, and/or understanding (of) [1]				
Content (Concepts)				
Process				
Nature of science				
Careers				
Community				
Engagement or interest (in) [2]				
Content (Concepts)				
Process				
Community				
Careers				
Skills [3]				
Asking questions				
Study design				
Data collection				
Data analysis				
Data interpretation				
Discuss results				
Disseminate results				
Using technology				
Writing				
Community				
Attitudes [4]				
Toward science				
Toward content				
Toward people				
About activities				
Toward species				
About careers				
About theories				
About community				
Behaviors [5]				
Time engaged				
Time outdoors				
Lifestyle changes				
Within community				
Community involvement				
Citizen action				
Responsible environmental behavior				
New participation				
Other [6]				
Social capital				
Community capacity				
Economic impact				

Following their methodology, the data captured by our Project Description Template (as shared in Appendix 1 above) can be further examined to identify potential indicators for each of these impact categories, followed by face-to-face discussions with WeObserve colleagues involved in those projects in order to achieve consensus on an appropriate evaluation measure. From this, we can determine the outcomes of each of the selected short list of COs as quantitatively as possible for the purposes of the '**D2.4 Landscape Repor**t'.

Evaluating Success - Cox's Citizen Science Success Matrix

In their case study of Zooniverse projects, Cox et al (2015)[67] ask how measures of success and outputs from a citizen science project can be defined, and then look at the relative positioning of Zooniverse projects against these measures of success. Because the two core aims and objectives of Zooniverse projects are to solve specific scientific problems, and to engage with the public in order to educate and change attitudes towards science, they selected 'Contribution to Science' and 'Public Engagement' as the areas within which they wanted to address the lack of common criteria for comparison of performance.

The performance indicators and means of measurement that they collated from a review of the literature are contained in Table 9 below.

[67] Cox, J. *et al*., "Defining and Measuring Success in Online Citizen Science: A Case Study of Zooniverse Projects," in *Computing in Science & Engineering*, vol. 17, no. 4, pp. 28-41, July-Aug. 2015. doi: 10.1109/MCSE.2015.65

TABLE 9: ELEMENTS OF CITIZEN SCIENCE SUCCESS MATRIX - COX ET AL. 2015

Table 1: Elements of citizen science success matrix

Matrix Element	Performance Indicator	Citations	Measurement	Proxy	Description
Contribution to Science	Data Value	Bonney *et al.* (2009) Cashnman *et al.* (2008) Cohn (2008) Dai *et al.* (2010) Gardiner (2012) Raddick *et al.* (2009) Riesch & Potter (2014) Sheppard & Terveen (2011) Silvertown (2009) Wiggins & Crowston (2011)	Publication Rate	$\frac{Number\ of\ published\ papers}{(Project\ age)^2}$	Total number of papers published divided by the square of project age. In fields where peer-reviewed journal articles are the norm, this includes only published or in-press peer-reviewed articles.
			Completeness of Analysis	$\frac{Number\ of\ classifications}{Target\ number\ of\ classifications}$	Total number of classifications received by the project divided by the target number of classifications per subject. The target is determined as the number of classifications per subject required to achieve an acceptable level of scientific and statistical validity.
			Academic Impact	$\frac{Number\ of\ citations\ per\ publication}{(Project\ age)^2}$	Total number of citations received per publication divided by the square of project age.
	Project Design and Resource Allocation	Dai *et al.* (2010) Franzoni & Sauermann (2014) Raddick *et al.* (2009) Rotman *et al.* (2012) Wiggins & Crowston (2011)	Resource Savings	$1-\left(\frac{\text{Active project duration}}{\text{One person workload}}\right)$	Active project duration divided by the number of *weeks* that a professional would need to work as *a full time (35 hours per week)* to complete all classifications recorded on the project.
			Distribution of Effort	$1-(Gini\ coefficient)$	Measures equality in the distribution of classifications across users.
			Effective Training	$1-\left(\frac{\text{Volunteers who only complete tutorial}}{\text{Total number of volunteers}}\right)$	The proportion of volunteers who go on to complete at least once classification after completing the tutorial. Note that we do not report data for some projects due to the absence of a tutorial or lack of reliable data on completion rates.
Public Engagement	Dissemination and Feedback	Bauer & Jensen (2011) Elam & Bertilsson (2003) Franzoni & Sauermann (2014) Powell & Colin (2008) Rotman *et al.* (2012) Silvertown (2009) Wiggins & Crowston (2010) Wiggins & Crowston (2011)	Collaboration	$\frac{Number\ of\ papers\ with\ citizen\ scientist\ coauthors}{(Project\ age)^2}$	Total number of papers where the list of authors contains at least one citizen scientist author divided by project age squared.
			Communication	$\frac{Number\ of\ project\ Tweets + blog\ posts + Talk\ posts}{(Project\ active\ period)^2}$	Sum total of project communication activity measured across multiple channels divided by project active period squared.
			Interaction	$\frac{Number\ of\ science\ team\ Talk\ posts + blog\ replies}{(Project\ active\ period)^2}$	Sum total of occurrences of interaction between the science team and volunteers divided by project active period squared.
	Participation and Opportunities for Learning	Bonney *et al.* (2009) Brossard (2005) Cronge *et al.* (2011) Phillips *et al.* (2014) Raddick *et al.* (2009) Trumbel (2000) Wiggins & Crowston (2010)	Project Appeal	$\frac{Number\ of\ volunteers}{(Project\ active\ period)^2}$	Total number of volunteers who have contributed to the project divided by project active period squared.
			Sustained Engagement	$\frac{Median\ volunteer\ active\ period}{(Project\ active\ period)^2}$	Median time interval (in weeks) between a registered user's first and last recorded classification divided by project active period squared.
			Public Contribution	$\frac{Median\ classifications\ per\ volunteer}{(Project\ active\ period)^2}$	Median number of classifications per registered volunteer divided by project active period squared.

These same performance indicators, where relevant, can feed into our evaluation of the short list of selected COs for the '**D2.4 Landscape Report**'.

Evaluating Citizen Science Activities - Kieslinger's Open Framework

A recent paper from Kieslinger et al[68]. has developed an Open Framework for evaluating Citizen Science activities that draws on a review of the literature, as well as in-depth interviews with a range of experts in the field.

Their evaluation criteria are structured along three main dimensions of participatory scientific processes, namely Scientific Aspects, Individual Actors, and the Socioecological/ Economic System, for which they propose criteria to be applicable at "process & feasibility" level as well as at "outcome & impact" level, as shown in Table 10 below.

TABLE 10: DIMENSIONS AND MAIN CATEGORIES OF THE CITIZEN SCIENCE EVALUATION FRAMEWORK - KIESLINGER ET AL. 2018

	Process & Feasibility	**Outcome & Impact**
Scientific dimension	• Scientific objectives • Data & systems • Evaluation & adaptation • Cooperation & synergies	• Scientific knowledge & publications • New research fields & structures • New knowledge resources
Citizen scientist dimension	• Target group alignment • Degree of involvement • Facilitation & communication • Collaboration & synergies	• Knowledge & attitudes • Behavior & ownership • Motivation & engagement
Socio-ecological/economic dimension	• Target group alignment • Active involvement • Collaboration & synergies	• Societal impact • Ecological impact • Wider innovation potential

Taking the more comprehensive criteria and supporting questions presented in their detailed Evaluation Framework[69], we will endeavour to apply this matrix to the selected short-list of COs across three key moments in the project lifecycle - the original strategic planning phase, the monitoring phase during the duration of the project, and the impact assessment phase upon completion of the project.

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[68] Kieslinger, B., Schäfer, T., Heigl, F., Dörler, D., Richter, A., & Bonn, A. (2017, September 20). The Challenge of Evaluation: An Open Framework for Evaluating Citizen Science Activities. https://doi.org/10.31235/osf.io/enzc9

[69] Kieslinger et al. 2017. *Table 3: Evaluation criteria and supporting questions (derived from literature review and proper experiences, critically reflected in expert interviews and stakeholder workshop)*

In doing so, we will collaborate with the authors of the framework to continue to develop it for different context and scenarios, and to add to its scope for non-static evaluation over time.

Evaluating Outputs - Wiggins' Science Products Inventory for Planning and Evaluation

Addressing the need for outcomes evaluations and productivity measures in Citizen Science that go beyond publications and citations, Wiggins et al (2018)[70] have developed a science products inventory tool to support general-purpose planning and evaluation of citizen-science projects. Their tool includes a collection of items for tracking the production of science outputs and data practices, and is shown in Tables 11 and 12 below.

TABLE 11: SCIENCE PRODUCTS - WIGGINS ET AL 2018

Category	Product	Definition
Written	Dissertations, theses (#)	Number of theses and dissertations using data from or reporting on the project
Written	Scholarly publications (#)	Number of published peer-reviewed science papers that report on the project or apply its data
Written	Reports (#)	Number of formal reports reporting results, such as white papers, technical, and other reports
Written	Grants awarded (#, $)	Existence (or total monetary value) of competitive funding awards from private or public funders
Data	APIs (Y/N)	Existence of technologies for automated data exchange between computers
Data	Data packages (#)	Number of curated exports of data and related documentation, usually as a downloadable zip file
Data	Metadata (Y/N)	Existence of documentation describing data structure, formats, and contents
Data	Visualizations (Y/N)	Existence of visual representations of data, such as graphs, maps, and animations
Data	Specimens/samples (#)	Number of material data points in the form of physical specimens or samples
Data	Requests (# requests, transfer volume)	Number of individuals or technical systems requesting data, or volume of transferred data
Management and Policy	Regulatory action (Y/N)	Existence of legal rulings or regulation enforcement based on project data and findings
Management and Policy	Decision support (Y/N)	Existence of decisions based on project data and findings (e.g., for policy or management)
Management and Policy	Forecasting/models (Y/N)	Existence of models based on project data that simulate or predict complex phenomena
Communication	Blogs (Y/N)	Existence of online informal written communications about project processes and findings
Communication	Newsletters (Y/N)	Existence of structured publications for project stakeholders, produced in hard copy or digitally
Communication	Videos (Y/N)	Existence of publicly available digital videos on project content, activities, and findings
Communication	Presentations (Y/N)	Existence (or number) of oral presentations at conferences or public events
Communication	Website (Y/N)	Existence of dedicated website for the project

[70] Wiggins, A., Bonney, R., LeBuhn, G., Parrish, J. K., & Weltzin, J. F. (2018). A Science Products Inventory for Citizen-Science Planning and Evaluation. BioScience, 68(6), 436-444.

TABLE 12: SCIENCE PRODUCTS - WIGGINS ET AL 2018

Category	Practice	Definitions
Findable	Data available from project website (Y/N)	Availability of data from the project's own website in a downloadable or queryable format
Findable	Data available from repositories or registries (Y/N)	Availability of data in a research data repository or via a data clearinghouse or registry
Accessible	Downloadable data file(s) available (Y/N)	Existence of download data files via project website, repository, or third party
Accessible	Tools for data exploration (Y/N)	Existence of tools for visualizing, summarizing, or querying project data via an app or website
Accessible	Data licensing specified (Y/N)	Existence of text specifying terms and conditions for data use
Accessible	Metadata available (Y/N)	Existence of documents with descriptive metadata such as known problems and data cleaning tips
Accessible	API documentation (Y/N)	Existence of documentation to support users of an API, where applicable
Interoperable	Data recorded in standard formats for discipline (Y/N)	Application of disciplinary standards for structural metadata and data formatting
Reusable	Uniqueness of data (describe)	Description of the unique contributions and features of the project's data
Reusable	Time scale of data (# yrs)	Number of years of records in the data set; may include historical data
Reusable	Spatial scale of data (describe)	Description of the geographic range for project data, such as continent, country, state, city, or watershed
Reusable	How much data (# data points, describe)	Description of data volume in terms relevant to the data collected, such as number of data points
Reusable	Errors documented (Y/N)	Existence of documentation for known errors in the data set
Reusable	Quality assurance or quality control documented (Y/N)	Existence of documentation for quality-assurance and quality-control processes
Reusable	Changes documented (Y/N)	Existence of documentation for data edited after initial receipt
Reusable	Questionable data flagged (Y/N)	Existence of documentation for data considered questionable or problematic
Reusable	Software or platform development (Y/N)	Existence of software or hosted technologies (platforms) that support external projects

We will apply these measures of science output to our own evaluation of the selected short-list of COs, for inclusion in the '**D2.4 Landscape Report**'.

APPENDIX 4 - Other Inventories of COs and Citizen Science Initiatives

As we conduct a review of the literature for the purpose of identifying a range of frameworks that can be used for the Landscape Reports, we are also logging references in the literature to other studies of a broad range of COs and Citizen Science projects, which may prove relevant for both the methodologies and frameworks used, and the outcomes of the comparative analysis. An overview of these studies and inventories are contained in this Appendix.

DG-ENV (Mudgal, Turbe, Arias, Robinson et al.) 2018 - 531 Projects & 40 attributes

A piece of research commissioned by the the European Commission Directorate General Environment is currently being undertaken by Bio Innovation Service SAS, Fundación Ibercivis, and the Natural History Museum (UK) to inventorise citizen science activities with an impact on environment policies.

We will coordinate closely with the researchers in order to share learning across these two projects, and where possible, incorporate their findings into the '**D2.4 Landscape Report'**.

Parrish et al 2018 - 500+ projects & 1 Typology

In their pending publication 'Exposing the Science in Citizen Science: Fitness to Purpose and Intentional Design', the goal of Parish et al (2018[71]) is to facilitate both acceptance and use of citizen science by the professional science community, and intentional design of projects with science as a primary objective by presenting a science-focused typology that differentiates projects based on intent and activity.

> "*We generated our schema through an iterative process ... tested against:*
>
> *(1) all projects (unique projects = 80) highlighted as examples in all previous literature proffering a typology or categorization of citizen science (i.e., see references above),*
>
> *(2) the 388 biodiversity citizen science projects collected in the Theobald et al. (2015) meta-analysis,*
>
> *(3) projects managed directly by the authors, and projects associated with and/or analogous to or duplicative of those projects (e.g., all projects focused on beach habitats; projects focused on documenting phenology), and*
>
> *(4) all projects on data collection platforms managed by the authors (e.g., in the Zooniverse). In total, over 500 projects were tested against our typology*[72]"

We will investigate the outcomes of their research further, to look for data or qualitative assessments of their project base that are relevant to our research.

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[71] Parrish, J. K., Burgess, H., Weltzin, J. F., Fortson, L., Wiggins, A., & Simmons, B. (2018). Exposing the Science in Citizen Science: Fitness to Purpose and Intentional Design. Integrative and Comparative Biology, Volume 58, Issue 1, 1 July 2018, Pages 150–160, https://doi.org/10.1093/icb/icy032

[72] Parrish et al. 2018

Pocock et al. 2017 - 509 projects & 32 attributes

In ‘The diversity and evolution of ecological and environmental citizen science’, Pocock et al. (2017)[73] conducted a systematic internet search and discovered 509 environmental and ecological citizen science projects. Each project was then scored for 32 attributes based on publicly obtainable information, using multiple factor analysis to summarise this variation to assess citizen science approaches.

The full results of this scoring, along with the time period of start and finish and six supplementary attributes as obtained from publicly-available information, can be found in the online S1 Dataset.

We will investigate this data set further, for input that is relevant to our research.

Palacin-Silva et al 2016 - 108 projects & 3 research questions

The Finnish Environment Institute undertook a systematic review of 10 years of citizen science literature, a comprehensive analysis of 108 Citizen Observatories, a survey, and interviews with stakeholders in Finland to gain broader understanding of the field country–wise. This study, culminated in the report ‘*State-of-the Art Study in Citizen Observatories: Technological Trends, Development Challenges and Research Avenues*’[74]

Their research questions were:

RQ1: What are the trends in citizen observatories in the world?

RQ2: What are the practices in citizen observatories in the world?

RQ3: What are the current and past initiatives in citizen observatories in Finland and Europe? RQ4: What are the current and past initiatives in citizen observatories in environmental observation in Finland and Europe?

RQ5: How to engage citizen?

Within this research, they also isolated results for European COs within their report, which will their analysis of 40 European Citizen Observatories (out of the total 108)[75] with regard to domain, are shown in Figure 8 below.

[73]Pocock, M., Tweddle, J., Savage, J., Robinson, L., & Roy, H. (2017). The diversity and evolution of ecological and environmental citizen science. PLOS ONE, 12(4), e0172579. doi:10.1371/journal.pone.0172579

[74] Palacin-Silva et al. 2016

[75] Palacin-Silva et al. 2016

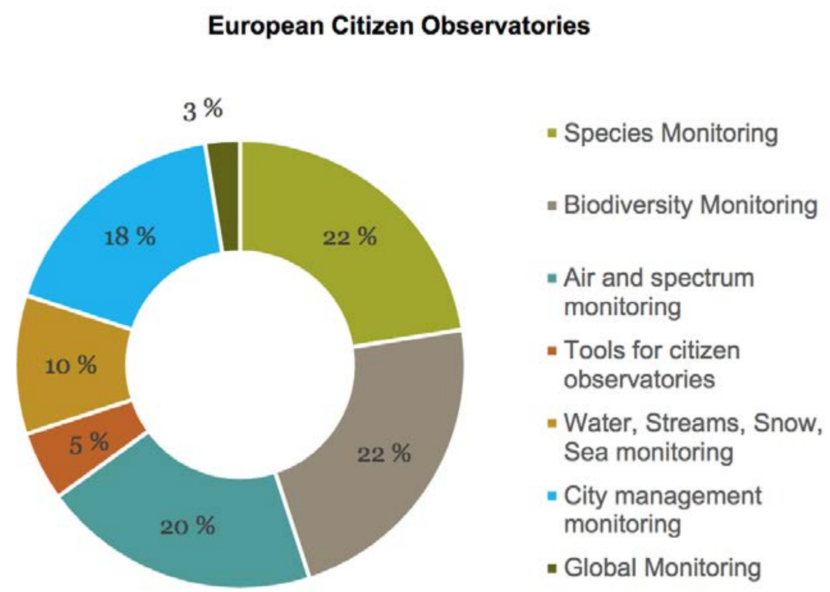

FIGURE 11: CITIZEN OBSERVATORIES IN EUROPE BY DOMAIN - PALACIN-SILVA 2016

We will draw on these findings in our own '**D2.4 Landscape Report'**.

Theobald et al. 2015 - 388 Projects & 3 Research Questions

In their paper '*Global change and local solutions: Tapping the unrealized potential of citizen science for biodiversity research*', Theobald et al.[76] report on the ambitious quantitative analysis of biodiversity citizen science that they undertook in order to ask three specific questions:

1. "What is the current scope of biodiversity citizen science, in terms of its spatial and temporal scales, diversity coverage (including taxonomic, genetic, and functional diversity), and economic worth of the volunteerism engaged?
2. To what extent is citizen science already integrated into peer-reviewed biodiversity research, and what factors influence the likelihood of publication?
3. What is the potential of citizen science for global change research, as measured by the rate of project initiation, relative to professional interest in biodiversity science?"[77]

Theobald et al have shared their supplementary data online at http://dx.doi.org/10.1016/j.biocon.2014.10.021, which we will investigate for synergies with our own research for the '**D2.4 Landscape Report**'.

[76] Theobald, E., Ettinger, A., Burgess, H., DeBey, L., Schmidt, N., & Froehlich, H. et al. (2015). Global change and local solutions: Tapping the unrealized potential of citizen science for biodiversity research. Biological Conservation, 181, 236-244. doi:10.1016/j.biocon.2014.10.021

[77] Theobald et al 2015

Conrad & Hilchey 2011 – 20 Community Based Monitoring Projects

In their review of citizen science and community-based environmental monitoring projects, Conrad and Hilchey (2011)[78] investigated the governance structures and their influence on conservation of 20 CBM programs. We will examine this data further for relevance to our own investigations for the '**D2.4 Landscape Report**'.

An Ecosystem of Citizen Observatories for Environmental Monitoring

[78] Conrad and Hilchey 2011